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FRANK NORMAN HOWES was born Aug. 2, 1901, at Richmond, Natal. Studied in the University of South Africa (M.Sc. 1923) and later as a post graduate student in the University of London. Eighteen months were spent on botanical work (mainly field work) in the Transvaal and Western Cape Province while attached to the Union Botanical Survey. Later held post of Economic Botanist, Agricultural Dept., Gold Coast and then appointed to the Staff of the Royal Botanic Gardens, Kew (Museums of Economic Botany). Visited Malaya, Java, Siam, Burma, India and Ceylon in 1928 in connection with work on banana varieties and disease resistance. Degree of D.Sc. (S.Af.) conferred 1935. Author of "Plants and Beekeeping", "Nuts", and numerous papers on economic botany. Member of the Imperial Institute Consultative Committee on Gums and Resins.

• A NEW SERIES OF PLANT SCIENCE BOOKS •

edited by Frans Verdoorn

Volume XX

VEGETABLE GUMS *and* RESINS

Collecting Mastic—drawing by **Emile Bayard**, after a sketch by Mr. **Testevuide** (ca. 1880).—The age long use of this fragrant resin in south eastern Europe and the Near East has been as a masticatory to sweeten the breath and preserve the teeth and gums. It is also used for high grade varnishes for special purposes such as those employed for the protection of pictures.

VEGETABLE GUMS
and
RESINS

by

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1949

WALTHAM, MASS., U.S.A.

Published by the Chronica Botanica Company

First published MCMXLIX
By the Chronica Botanica Company
of Waltham, Mass., U. S. A.

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Made and printed in the U. S. A.
Designed by Frans Verdoorn

Preface

The vegetable gums and resins constitute an important group of economic plant products and are utilised in many ways. Their uses by man, in fact, go back to the earliest times. In modern industry large quantities of both resins and gums have been used for many years in manufacturing processes of various kinds. Their uses continue to increase. The world trade in natural resins has been estimated to be in excess of three quarters of a million tons per annum. The value of the yearly import of gum arabic into Great Britain alone in normal times has commonly been in excess of a quarter of a million pounds sterling. This does not include the various other gums that are in regular use.

The terms "gum" and "resin" are often used in a somewhat indefinite or vague manner. They have been applied to almost any form of plant exudation, even to those that are of a predominantly rubbery nature. The wild or jungle rubber industry that thrived in the past in many parts of the world and was revived during the Second World War, was often referred to as the "gum industry" and those engaged in it as "gum collectors." "Chicle gum" and "balata gum" are expressions frequently heard at the present time. In addition to its use in connection with rubbery exudations of this kind, the word "gum" is also applied to some of the true resins, as in "gum copal," "gum accroides," "kauri gum" and "varnish gums," where the resins employed in varnish making are intended. Fortunately, this misuse of the term "gum" appears to be on the decline.

In this work the words "gum" and "resin" are used only in the more correct or technical sense. No attempt has been made to deal with the large group of substances of a rubbery nature sometimes called "gums." A simple, if incomplete, distinction between gums and resins is that the true gums are more or less soluble in water or swell to a jelly-like mass but remain insoluble in organic solvents, whereas the resins are unaffected by water, but are more or less soluble in various organic solvents. Some plant exudations consist, in the natural state, of a mixture of both gum and resin and are styled gum-resins. The term oleo-resin is used for those resins—of a more or less soft consistency—that occur mixed with a relatively large amount of essential oil. Some resinous plant exudations, particularly those that are medicinal, consist of mixtures of resin, gum and oil, and may be termed oleo-gum-resins.

The number of species that yield gums or resins in greater or less amount throughout the Vegetable Kingdom must be many thousands. For this reason a selective treatment has been necessary in this work. Special emphasis is placed on those gums and resins that are of commercial importance, or which for some reason or other are of special interest. Particular attention has been given to those that have only become of commercial importance in comparatively recent years, and which are not dealt with in older works of reference. Examples of these are carob seed or locust gum, karaya or Sterculia gum and other tragacanth substitutes, also certain Acacias now known to be exploited for gum, particularly in East Africa.

Owing to the fact that the true gums as a group have entirely different properties and uses from the resins and interest different classes of users, it has been considered desirable to treat the two groups separately. The book has, therefore, been divided into two parts.

Among peoples all over the world, including the aboriginals of Australia and primitive African and Asiatic tribes, certain gums have been used for food as far back as history relates. The adhesive properties of gums have also been utilized from early times, particularly in preparing paints and pigments. Gum arabic in North Africa has been an article of commerce from at least the first century of the Christian era and the trade existed throughout the Middle Ages. The Sudan gum arabic trade with European and other countries developed steadily during the last century, in spite of temporary set-backs through political disturbance, and reached still greater proportions in the present century, thanks largely to improved transport facilities (railways) in the producing areas.

The uses of resins by man are of equal antiquity to those of gums. Many have good combustible properties and have been used for torches and for lighting from time immemorial, particularly by the Malays and other Asiatic and Pacific races. Primitive peoples also commonly make use of resinous materials for caulking their boats. Several of the resins or oleo-resins of the Mediterranean region and near East have long been esteemed for their medicinal properties or their fragrance and hence their age long use for religious purposes (incense). Varnishing or varnish making has always been one of the important uses for vegetable resins and this goes back to early times in some countries. The Ancient Egyptians employed resin (probably a crude oleo-resin) for coating or varnishing mummy cases. There is also evidence that the Incas of South America used embalming resins. It is known that oleo-resins were distilled in Europe in the Middle Ages. The early painters had many formulae and recipes in which the resins and oleo-resins then available, such as mastic, sandarac and pine resin, were ingredients.

With regard to modern uses of vegetable resins the paint, varnish, linoleum, paper sizing and soap making trades use considerable quantities. The relative amounts of the different kinds of resins used for industrial purposes in the past have varied considerably as perusal of the following pages will show. At one time it was thought synthetic resins would completely replace natural resins for many purposes, particularly in the paint and varnish industries, but this has not materialised and the natural resins continue to hold their own and to be imported into manufacturing countries in large quantities. What the future will hold no one can foretell, but in the light of recent developments there are strong indications that the use of natural resins will increase rather than diminish. Recently research has developed new types of resin which are combinations of synthetic and of natural resins, the best examples being the so-called "copal type synthetics."

These resins are proving very promising. They combine desirable features of both the synthetic and the natural or fossil resins.

There have been many important contributions to the literature of vegetable gums and resins, alike from the chemical and physical, and the botanical aspects. A few comprehensive works have appeared in book form and many notable contributions are to be found scattered over a wide range of literature and in periodical publications of all kinds.

With regard to gums, an account of the gums of India was given by Dr. M. C. Cooke, in 1874, from the information then available. This was augmented to some extent a few years later by Dymock Warden and Hooper in their memorable Pharmacographia Indica, and by Watt in his well known Dictionary of the Economic Products of India. At about the same time, J. H. Maiden and his co-workers were making a study of the exudations of Australian plants and published many detailed accounts of the gums and resins of that Continent. In 1909 the Imperial Institute published a special report on "Gums and Resins" which included much useful general information and also accounts of investigations carried out at the Imperial Institute on gums and resins from various parts of the world. Since that time numerous articles on gums have appeared in the Bulletin of the Imperial Institute. In 1911, H. J. de Cordemoy's "Les Plantes à Gommes at à Resines" appeared, and in 1920 a small book by E. J. Parry intended for the general reader was published. Five years later a comprehensive monograph on gum arabic by H. S. Blunt, who had spent many years in the gum producing districts of the Sudan, made its appearance. The East African Acacia gum industry was dealt with in some detail by D. W. Malcolm in 1936.

During the last two decades notable contributions to the chemistry of some of the better known vegetable gums have been made, both in Europe and the United States. Special attention has been given to those gums (mannogalactans) used as stabilizing and thickening agents in various food products. Much of this work has been summarized by A. G. Norman (1937), who points out how much awaits investigation in this particular field. Another admirable account of recent work on gums has been given by C. L. Mantell (1947). What is known of the chemistry of all the more important gums (and vegetable mucilages) used in industry is dealt with by this writer.

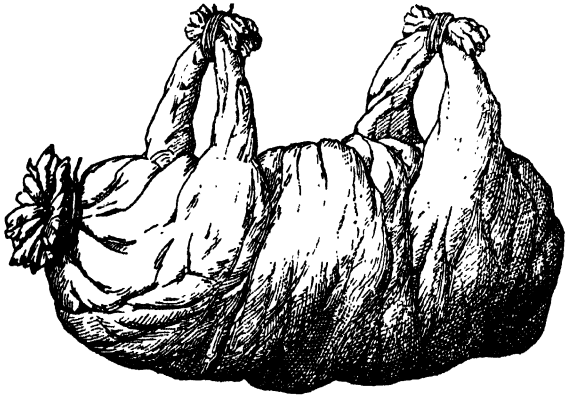
Turning to resins, much of the existing knowledge, particularly in relation to their chemistry, is due to the investigations of Prof. A. Tschirch of Berne, the gifted chemist, botanist and pharmacognosist. His work was carried on by collaborators after his death. Tschirch's well known and comprehensive work "Die Harze und die Harzbehälter" first appeared in 1900, with a considerably enlarged edition, in two volumes, in 1906. A third revised edition appeared in 1933-36. Other notable contributions to the literature of natural resins have been "Die Natürlichen Harze" by H. Wolff in 1928 and "Natural Varnish Resins" by T. Hedley Barry in 1932, both these writers being well known authorities on resins. The commercial manufacture of varnishes is a complex and highly technical subject with a literature of its own, recent or well known contributions being those of W. Krumbhaar (1947), H. W. Chatfield (1944), Mantell (1942),

R. S. MORREL (1923), and J. GAULD BEARN (1923). In recent years some of the commercial resins have received more attention than others, both from the laboratory worker and the worker in the field. The literature on colophony or pine resin is now very extensive. Belgian workers have added much to the knowledge of Congo copal. "Manila" or East Indian copal and its exploitation has been closely studied by C. VAN DE KOPPEL, while T. A. BUCKLEY has given a detailed account of the various Malayan dammars. Lac in India has been the subject of much promising work, thanks to the Indian Lac Research Institute, and to workers in Great Britain and the United States.

A word of explanation may be desirable in connection with the use of botanical names in this book. As the average reader is not likely to be interested in the authority for the name but only in the plant itself or its product, the authorities have been omitted purposely from the text. They are, however, available for those who may require them in the index of botanical names at the end of the book.

The writer is indebted to the Director of the Royal Botanic Gardens, Kew, and to the Director of the Imperial Institute, South Kensington, for the use of specimens and for other facilities afforded by these two Institutions, also to colleagues and to various firms connected with the gum and resin trade for information and assistance willingly given.

THE AUTHOR.



DEDICATED TO THE COLLECTORS OF GUMS AND RESINS
IN ALL PARTS OF THE WORLD, MANY OF WHOM,
ESPECIALLY ON THE AFRICAN CONTINENT,
LIVE IN HUMBLE CIRCUMSTANCES
AND CARRY OUT THEIR WORK
UNDER ARDUOUS CONDITIONS

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Vignettes by WINIFRED WALKER

COLLECTING FRANKINCENSE

Woodcut from PARÉ'S *De Distillationibus (1582)*

Part I

GUMS

Chapter I

THE NATURE AND USES OF GUMS

The Occurrence and Origin of Gum in Plants:—The vegetable gums are a group of plant products resembling carbohydrates and widely distributed in the Vegetable Kingdom. They are characterized by the ability to dissolve in water forming viscid solutions, or by absorbing water to form jellies or gelatinous pastes as in tragacanth and allied gums. On desiccation or exposure to the air these solutions or pastes lose their water and dry to hard, clear, rather glassy masses.

Gums are to be found in a greater or less degree in most plant families. Various organs of the plant may produce or secrete them. They may be produced only in very small quantity and not be readily discernible, or they may be produced very copiously forming large, conspicuous incrustations on the surface, as with most of the commercial gums, particularly the tree gums. Certain families of flowering plants are notable for the number of species they contain that are free gum yielders. Notable among them is the *Leguminosae*, in which a hundred or more species of *Acacia* alone are known to yield gum, including those that are commercially important for gum arabic. Several species of *Astragalus* are also free gum yielders and are the source of gum tragacanth. The following are additional notable gum yielding genera in the family—*Albizzia, Bauhinia, Caesalpinia, Ceratonia,* and *Pithecolobium.* Other important gum yielding families are—*Anacardiaceae, Combretaceae, Meliaceae, Rosaceae* and *Rutaceae.*

Various views have been put forward concerning the processes whereby gum is formed in plants. In some instances it is believed that gum is part and parcel of the normal metabolism of the plant and is in every sense a natural or physiological rather than a pathological product. While some vegetable gums may originate in this manner and be part of the normal cell content, as in the case of the gums in sugar beet and yeasts, it is now generally agreed that most gums owe their origin to infection of the tissues by some form of micro-organism (A. C. Thaysen and H. J. Bunker, 1927). In some cases the production of gum has been attributed to fungi attacking the plant, these fungi being responsible for enzymes that penetrate the tissues and transform the celluloses and hemicelluloses of the cell wall into gum. This may be the origin of the gum produced in the "gummosis" diseases of certain deciduous and other fruit trees. In other cases, particularly with species of *Acacia,* gum formation has been attributed to bacterial action and it has even been claimed that specific bacteria are capable of producing different kinds of gum, but as yet there is little concrete evidence in support of this. It has even been suggested that a system of inoculating trees to induce a regular and uniform production of gum might eventually be possible, but no progress has so far been made in this direction.

The bacterial origin of gums was first studied by R. GREIG SMITH (1902) in Australia and later by J. S. BLUNT (1926) and others, in the Sudan. The views of the last mentioned in regard to the bacterial origin of gum arabic in the Sudan are of special interest. He points out that *Acacia senegal* (syn. *A. verek*), the source of the best gum arabic, does not yield gum when in a state of active healthy growth with an abundance of soil moisture and soil nutrients, but only in a state of poor vigour or an unhealthy condition. This may be due to poorness of soil, a common occurrence in the Sudan as the "gum gardens" are often established on land that has become worn out through frequent cultivation of other crops, or to lack of moisture, also a common occurrence, and accentuated by the competition from grasses. It has been found that when gum arabic trees are specially cultivated, and thrive accordingly, or where they are growing near water they remain green most of the year and do not give off gum. When such trees are tapped they appear "to be able to heal quickly and to stave off infection." Callus formation is rapid in such trees. The view is held that the bacterium responsible for the production of gum is always present but whether it is active depends upon the condition of the tree and its environment. If infection were to take place from one tree to another there are many agencies that would cause this. The actual act of tapping as carried out by natives with their implements may cause infection. Ants are common over the wet surface of the wound immediately after tapping. Beetles frequently attack the trees and grazing animals (camels) tear off small branches and twigs.

While some hold the view that the production of gum in Sudan gum arabic trees is due to bacterial agency there are others (D. W. MALCOLM 1936) that consider the gum to be a normal product of plant metabolism, produced in response to physiological disturbances induced by drought. They argue that it can hardly be maintained that all, or even the majority of trees yielding gum arabic are unhealthy when *Acacia senegal* has survived and multiplied in spite of being continuously subject to drought and tapping. The real cause of the production of gum in Acacias and many other trees must therefore remain uncertain for the present.

The origin of gum tragacanth and some of the allied gums is of a fundamentally different nature from that of the Acacia gums. True gum tragacanth (*Astragalus* spp.) is produced inside the plant by the transformation of the cell walls and adjacent layers of the medullary rays and the pith into gum. This readily absorbs water causing it to swell and exert pressure on the surrounding tissue. With the consequence that eventually it oozes from the stem of its own accord or as a result of injury or deliberate wounding. The pressure may be so great that a piece or strip of gum 2 cms. long may be exuded in as short a period as half an hour from longitudinal incisions, as in tapping. The gum often contains starch grains in appreciable quantity which were present in the original cells. In this respect the gum differs markedly from the Acacia gums. Little is known of the factors that cause the original gummosis of the cell walls, although fire may act as a stimulus. The rapidity with which the gum exudes determines its shape and to some extent its colour.

The Different Kinds of Gum:—Gums exhibit endless differences in general appearance, especially colour, and in physical and chemical properties, such as the more obvious and commercially important ones of viscosity or adhesiveness and solubility. All are readily distinguished from resins, oleo-resins and balsams and products of a rubbery nature to which the term "gum" is sometimes wrongly applied, by the fact that they are miscible with water in all proportions and are insoluble in liquids such as alcohol, benzene, ether, chloroform, turpentine and fixed oils which dissolve resins.

The true gums are generally divided into two main classes or groups—*a*) *soluble gums:*—typified by gum arabic and similar gums, which dissolve in water forming more or less transparent, viscous and adhesive solutions, and *b*) *insoluble gums:*—which, when placed in water absorb it and swell into a thick jelly or jelly-like mucilage or with sufficient water present finally break down into a very thick translucent solution. The best known gums belonging to this group are gum tragacanth and the so-called "tragacanth substitute" gums such as karaya gum, carob seed gum and hog gum or kutira gum. Gums of this class are yielded by several species of *Sterculia* (*see* Chapter III).

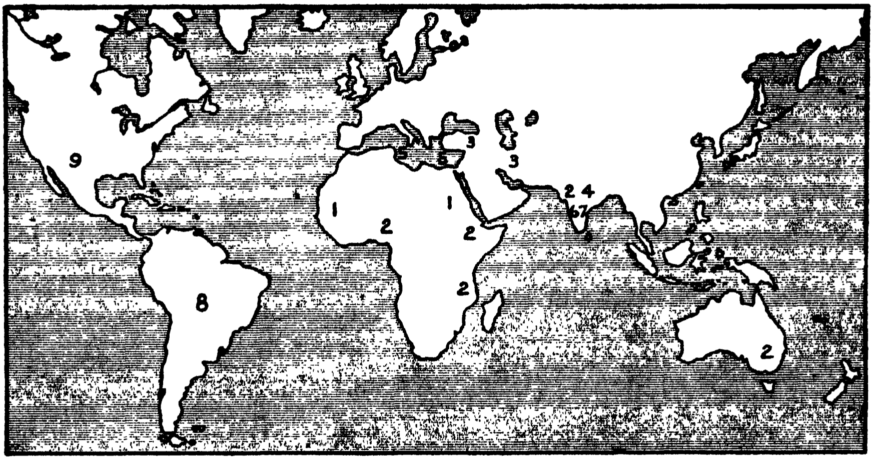


FIGURE 1.—MAP SHOWING THE DISTRIBUTION OF THE MORE IMPORTANT VEGETABLE GUMS: 1, Gum Arabic (*Acacia senegal* Willd.); 2, Other Acacia Gums; 3, Gum Tragacanth (*Astragalus* spp.); 4, Indian Tragacanth or Karaya Gum (*Sterculia urens* Roxb.); 5, Carob Seed Gum (*Ceratonia siliqua* L.); 6, Kutira Gum (*Cochlospermum gossypium* DC.); 7, Gatty Gum (*Anogeissus latifolia* Wall.); 8, Angico Gum (*Piptadenia* spp.); 9, Mesquite Gum (*Prosopis juliflora* DC).

There is also what might be considered to be a third groups of gums—gums with properties intermediate between the above two classes. These have been termed "semi-insoluble gums." They partially dissolve in water leaving a swollen jelly, which will pass into solution with the addition of more water, *i.e.* they form thin jellies. The so-called "Persian insoluble gum", believed to be derived from a species of *Prunus* and largely imported from the Persian Gulf at one time, is a good example of this class of gum.

Commercially, such gums are considered inferior to both tragacanth and gum arabic.

Physical Properties:—The physical properties of gums are of first importance in determining their uses and their commercial value. Not only do these vary considerably with gums of different botanical origin, but it has been shown there may be noticeable differences in the gum from the same species when collected from the plants growing under different climatic and edaphic conditions or even when collected from the same plant at different seasons of the year. The age of the gum when collected, *i.e.* the length of time it has remained attached to the tree after secretion, may also affect some of its physical properties. Another consideration is the treatment the gum may receive after collection such as washing, drying and bleaching in the sun. Storage temperatures may also play a part.

The following are some of the main physical properties of gums:—

Colour and form.—The colour of gums (in the solid state) varies from almost water white through various shades of yellow, amber and orange to dark brown. Some of the best grades of gum arabic are almost colourless, possessing but faint traces of yellow. On the other hand, dark, brownish-black or even black gums sometimes occur. Certain gums possess a pink, red or greenish hue. Mesquite gum (*Prosopis juliflora*) is often distinctly red, so also is the gum of some Acacias. The statement has been made (J. von Wiesner 1927), that completely colourless gums do not exist, but this is open to question. Some gums when first secreted appear superficially to be quite colourless. Colour is mainly due to the presence of impurities of some form or other, but the colouring matter in gums has been little investigated. Often it only appears as the gum ages on the tree and may be due to substances washed on to the gum. Scorching from bush or grass fires darkens gums. Tannin from the sap or tissues of the parent plant is not infrequently the cause of discoloration and is believed to account for some of the very dark gums yielded by certain trees. Tannin or tannic acid in gum intended for commercial use is undesirable for it is liable to affect the mordants used in calico printing. Distinctly coloured and almost colourless gums have sometimes been obtained from the same tree, *e.g. Sterculia urens.* Colour is of great importance in the commercial valuation of gums, a strong preference being always shown for those that are light coloured. Some interesting observations have been made by Blunt regarding the factors influencing the colour of gum arabic in the Sudan, *e.g.* "The best gum is practically colourless, and is usually collected off geneina or garden gum, where the trees are growing on old cultivations. Then there are also the pale rose pink, darker pink, and yellowish. The hard gum is of the pink variety, whereas, the yellowish gum is very friable. To fix a hard and fast rule as to the reason for the differences in colour is very difficult; the pinkish colour is derived to some extent from the pink undersurface of the bark, which probably also contains different quantities of tanning material. It is without doubt that old trees give off a dark gum. After extensive observations made by the author, it appears that the old wood will give off a pinkish coloured gum, whereas the new wood, *i.e.* the branches, give off a colourless or very light pink gum. To a certain extent therefore the variability in colour is due to the age of the part of the tree that is tapped."

Gums as seen or collected in the natural state are represented by a variety of shapes and forms. Usually the fragments are irregularly globular or drop or pear shaped, well exemplified in the various commercial grades of gum arabic. Some gums however, are characteristically stalactitic in shape and after collection and the inevitable fracturing that occurs, have the appearance of irregular rod-shaped fragments, a good example being cashew gum (*Anacardium occidentale*). The tragacanth gums exhibit very characteristic shapes and may be leaf or thread-like in appearance according to the method of collecting or tapping. The surface of most gums when fresh is perfectly smooth, but this may soon become rough or covered with minute cracks or striations due to weathering. This gives an opaque effect, well exemplified in some grades of gum arabic, *i.e.* "ripened" gum. The fissures or striations are frequently restricted to the surface, but in some gums they are deep seated and may assist in causing the tear to break up into smaller fragments in the course of handling, transportation, etc.

Taste and smell.—The true gums are generally scentless or nearly so, and in this respect differ markedly from some of the resins and oleo-resins that are so distinctive in smell. They may be tasteless, and are in fact generally devoid of any characteristic taste apart from being blandly mucilaginous, but some are slightly sweet or bitter according to botanical origin. In some gums there is a distinctly bitter after-taste that clings. This is a serious disadvantage in a gum required for edible purposes, such as the manufacture of gum lozenges or pastilles.

Hardness and density.—Gums vary in hardness, but attempts to classify them according to hardness, as has been done with minerals, in order to use hardness as a diagnostic character in identifying gums have not proved at all satisfactory (J. von Wiesner 1927). Hardness is obviously governed partly by the amount of moisture present. This generally ranges between 12 and 16%. Density also proves variable in one and the same gum according to the amount of air that may have become incorporated with it when it was formed. Most gums break with a clear glassy fracture when properly dried, and may be readily pulverized, a form in which they are frequently used. Gums of the tragacanth type are not so readily pulverized.

Gums are in the main hygroscopic and will absorb moisture and become soft in a humid atmosphere. This power to hold water or to lose it may have important repercussions in the gum trade. In the Sudan for instance it has been found that on a long camel journey in the dry season gum arabic may lose up to 5% in weight. In the rainy season, on the other hand, it may gain in weight. According to Blunt this "gaining and losing of weight will always make the trade a gamble" and "gum which has dried in transmission to Europe, and if warehoused in the humid atmosphere of England may not only gain back the weight lost but gain still further in weight."

Polarization.—In aqueous solutions gums are usually weakly lævorotatory but some Acacia gums have been recorded to be dextrorotatory.

Solubility.—Most gums yield a certain amount of insoluble residue when mixed with water. In general this is greater in amount with the dark coloured gums than with the pale or light coloured and is important in the commercial valuation of a gum sample. The solubility of a gum may be influenced by age and the time it is attached to the tree.

Viscosity and tenacity.—Viscosity or the "thickness" of a solution that a gum forms with water is of paramount importance in determining the quality or value of a gum. The higher the viscosity the better the gum. There are various methods of estimating this, but usually some form of standard viscosimeter is used. The tenacity of gums is usually considered along with viscosity; the greater the tenacity the greater its value; the value of gums for adhesive purposes being dependent upon this character.

Colloidal nature.—The viscous solutions of gums in water are colloidal in nature. They exhibit swelling pressures and form gel structures at very low concentrations and over a wide range of concentration. They have low surface tension, do not crystallize and act as protective colloids and stabilizing agents. In effect they prevent the agglomeration and settling of finely divided particles or precipitates. It is this property that renders gums valuable in so many manufacturing processes, notably in the textile, cosmetic, pharmaceutical and food industries (MANTELL, 1947).

Chemical Properties:—Vegetable gums are composed of carbon, hydrogen and oxygen with small quantities of mineral matter or "ash constituents" and sometimes a little nitrogen. Small quantities of tannin may also be present in some gums. Being uncrystallizable and freely miscible with water gums closely resemble gelatin and glues. However, the nitrogen, when present, is small in amount and is not regarded as an essential constituent, being more in the nature of an impurity. Gelatin or glue on the other hand contain considerable quantities of nitrogen and it is this that renders them fundamentally different from gums.

The views that have been held in the past regarding the chemistry of gums have passed through various stages, and a good account of them has been given by H. H. ROBINSON (1906). He points out that the work done in the earlier part of last century led to the recognition of three basic gum substances believed (at the time) to be individual chemical compounds and that one or the other was a component of all gums. These were "arabin" (from gum arabic), "cerasin" (from cherry gum) and "bassorin" (from "gum Bassora", a tragacanth-like gum). However, it is now known that the number of gum compounds is very considerable. Consequently, little credence can be placed on the references to "arabin," "cerasin" and "bassorin" that occur so freely in the older literature on gums. It is considered that it is the uncrystallizable properties of gums, rendering their purification difficult and uncertain, that have been the cause of their chemistry being uncertain for so many years.

Until about the end of the last century it was believed that gums were simply carbohydrates, substances similar to sugar, starch and cellulose and the formula $C_{12}H_{22}O_{11}$ or $(C_6H_{10}O_5)n$ assigned to them. It was later shown however, that gums were not carbohydrates but complex acids built up of a nucleus acid combined with several of the less common sugars. Among the nucleus acids are arabic acid (gum arabic), geddic acid (Gedda gum) and bassoric acid (gum tragacanth and allied gums). Investigations have shown that the properties of the gum of a plant, taken at different seasons, may not always be the same, due to the fact that there may be variation in the proportions of the sugars united to the nucleus acid to form the natural complex gum acid, and in the proportions of the complex acids in the mixture that constitutes the natural gum. (Bull. Imp. Inst. 6:32-33).

On hydrolysis with dilute mineral acids the gums form various sugars such as the pentoses, arabinose, xylose, tragacanthose and the hexose galactose. Hydrolysis causes them to largely lose their characteristic tenacity. Not all the gum is converted into sugars but usually about 20% resists treatment. This is the organic acid with which the various sugars were combined. Gums may therefore be considered to consist of glucosidal acids of high molecular weight. In most gums the acids are partly combined with calcium, potassium or magnesium in the form of salts; but in some gums they may be present largely in the free state. In gum arabic, each molecule of the glucosidal acid (termed arabic acid), yields on hydrolysis, two molecules of arabinose and four of galactose.

The so-called "artificial gum" or "British gum", which is dextrin produced from starch, differs from gum in being wholly converted into dextrose on hydrolysis. It is also strongly dextro-rotatory, whereas natural gums are invariably slightly lævo-rotatory.

Among the reagents sometimes used in the examination of gums, and which may be of assistance in identifying a gum when the number of possible botanical sources is known and restricted within reasonable limits, are the following:—neutral and basic lead acetate—either will give a precipitate with aqueous solutions of some gums but not others: borax and ferric chloride—both cause gelatinization of some gums but not others. J. F. CAIUS and K. S. RADHA (1939) have drawn up a key for the identification of the various Indian gums found in the shops and bazaars of Bombay, and this is largely based on the use of these reagents.

In recent years substantial advances have been made in knowledge of the chemistry of the gums, particularly those that are important in industry. Good accounts or good summaries of this work have been given by MANTELL (1947) and by NORMAN (1937), to whom the reader is referred. It is generally agreed, however, that much remains to be done in the chemical field, particularly with regard to the less common gums. As the different gums or different classes of gum differ markedly in their chemical properties and in chemical composition they are best considered separately.

Gum arabic.—As with other gums commercial gum arabic may be derived from various geographical sources and possibly from more than one botanical source or species of *Acacia*. It is therefore subject to a fairly wide degree of variation and is not a substance of empirical composition. Interesting data on the probable molecular structure of gum arabic and its physico-chemical behaviour has been brought to light in recent years. The gum arabic "molecule", in structural complexity, is considered to stand between hemicellulose and the simple sugars (MANTELL, 1947). The molecular weight has been demonstrated to be of the order of 240,000 and the equivalent weight of the gum acid 1000 to 12000. Gum arabic is essentially a mixture of calcium, magnesium and potassium salts of arabic acid. HIRST (J. Chem. Soc., 1942, pp. 70-78,) considers constituents to be — 1*d*-glycuronic acid, 3*d*-galactose, 2*l*-arabinose, and 1*l*-

rhamnose. From the hydrolization of gum arabic a crystalline aldobionic acid has been isolated.

In connection with the study of the chemical properties of gum arabic its viscosity, being important in utilization, has received a good deal of attention and study. Viscosity varies much with different grades of gum arabic and even different consignments of the same grade show wide variation. This is attributed to such probable factors as earliness or lateness of the season when collected, age of the trees, climatic or edaphic conditions generally and the storage conditions or length of storage. One of the valuable features of gum arabic from the industrial point of view is the retention of high viscosity over wide ranges of *pH* and in mixtures with other emulsifying agents. It is commonly mixed with tragacanth and with agar-agar in making emulsions but cannot be used with soap. The incompatability of the gum with soap is considered to be due, in part at least, to its calcium and magnesium content. Temperature affects the viscosity of gum arabic solutions as well as the density. The addition of salts also depresses the viscosity. If, in dissolving gum arabic, the whole of the water is used at the outset a higher viscosity is said to be obtained than when part of the water is added later (MANTELL, 1947).

Gum tragacanth.—The composition or chemical structure of gum tragacanth does not appear to have been altogether satisfactorily ascertained. MANTELL (1947) states that "Like gum arabic, gum tragacanth is of carbohydrate nature and has acidic components which are largely present as calcium, magnesium and potassium salt. In tragacanth the gum consists of a soluble portion, called "tragacanthin", and an insoluble portion, called "bassorin", the latter constituting 60 per cent to 70 per cent of the total. NORMAN believes the soluble constituent to consist of a ring containing 3 molecules of glucuronic acid and 1 molecule of arabinose with a side chain of 2 molecules of arabinose. The soluble portion gives a colloidal hydrosol solution with water while the insoluble part swells to form a gel. Introduced into water, gum tragacanth absorbs a large amount of the water and swells greatly to form a soft adhesive paste, but does not dissolve. If agitated with additional water, the paste forms a uniform mixture but after 1 or 2 days the greater part separates out and leaves the rest dissolved. Tragacanth is wholly insoluble in alcohol. Its ability to swell in water to form a gel of high water content (or conversely of low gum content) and the ability of these gels to give unique viscosity, emulsion stabilizing and demulcent behaviour account in large measure for its extensive use." According to the British Pharmaceutical Codex (1934) that portion which is soluble in water "appears to consist chiefly of polyarabinantrigalactangeddic acid and yields on hydrolysis arabinose, galactose and geddic acid. The portion insoluble in water yields, under the influence of baryta water, isomeric α- and β-tragacanthanxylanbassoric acids, which yield on hydrolysis tragacanthose, xylose and bassoric acid."

The viscosity of tragacanth has been studied by a number of workers and the results summarised by MANTELL (1947). The demulcent action of the gum is related to its high viscosity and other colloidal properties. Tragacanth is normally acid in reaction. It is reputed that neutralization results in decreased viscosity, and that viscosity is at a maximum at about *p*H 8, dropping sharply at either side. The addition of certain salts, notably sodium chloride, also reduces viscosity. Boiling of a tragacanth mucilage results in increased viscosity, though not for long. Mechanical treatment — passage through a homogenizer — may also increase viscosity. According to ROWSON (*Quart. J. Pharm.* **10**:404, 1937) a mixture of gum tragacanth and gum arabic mucilage has a lower viscosity than that of either constituent mucilage, the decrease in viscosity being due to a dehydration of the gel masses of tragacanth and their appearance as white floccules. However gum arabic and tragacanth are often used together to obtain stability of emulsions, tragacanth alone producing coarse emulsions.

Other commercial gums.—The chemistry of other commercially important gums such as Karaya gum, Carob seed gum or Locust gum and Indian Gatty gum has received the attention of a number of different workers in recent years, particularly in the United States, and the results summarised by MANTELL (1947). Although Indian Gatty gum is largely derived from *Anogeissus latifolia* there is no doubt that gums from entirely different botanical sources are often referred to as Gatty gum by Indian gum merchants and are exported under this name (*see* page 54). It would seem therefore that chemical work on ordinary commercial samples of Gatty gum is hardly likely to achieve useful results and that steps should first be taken to ascertain definitely the botanical source or to make sure that the gum is that of *Anogeissus latifolia* and not that of some other species that may have been substituted.

The Commercial Valuation of Gums:—For many years gum arabic from the Sudan and to a less extent from Senegal has been available in fair quantity and of good quality. It has also been marketed in European and other markets at a relatively low price. This has resulted in there being little or no demand for inferior or darker coloured gums, even though they belong to the gum arabic class and are derived from Acacias. This has meant there has been no commercial outlet whatsoever for the poorer quality gums derived from other botanical sources and which in addition to possessing a darker colour than the average grade of commercial gum arabic are generally inferior in solubility, viscosity or adhesiveness. Such gums have sometimes been offered on the London markets at 7/- to 9/- per cwt., but without buyers, while Kordofan gum arabic fetched 30/- to 32/- per cwt.

Colour and viscosity are probably the two most important factors in accessing the value of a gum, but good solubility is also important. Some gums are inclined to be very gelatinous when dissolved in water. This is objected to, especially for large scale confectionery purposes, for it hinders proper purification and renders them difficult to pour. It also makes them more difficult to handle as an adhesive. The final test for any gum is of course an actual commercial trial for the particular purpose for which it is required. In gum used for edible or pharmaceutical purposes great stress is laid on taste, or rather the absence of it.

Buyers and users of gum, except for a few specialized purposes, always attach great significance to colour. The paler the gum the higher its value is likely to be, assuming there are no other objections to it and the sample is reasonably clean. Good viscosity is important for so many of the purposes for which gum is used and often it is necessary to use the gum in strong solution.

In earlier days, *i.e.* two or three generations ago, when good quality gums were not so plentiful as they are now and much higher prices were paid for them the question of adulteration played a much more important part than it does at the present time. With good quality gums now available cheaply, adulteration is not worth while. Furthermore in the Sudan, which now produces the greater part of the worlds' supply of gum arabic, Government control is exercised to prevent all forms of malpractice as far as possible.

The grading of gum may either be carried out in the country of origin or in the country to which it is exported. With gum arabic the gum may be sun-bleached before export. Cleaning and sifting, to remove particles of bark and sand or earth, may also be carried out as a preliminary to grading. Grading is usually done for colour and size of tear or fragment and may involve, more or less, the individual handling of each piece. The number of grades employed varies with different countries and may even run into dozens. The better grades show uniformity in size of fragment and are pale in colour with an absence of dust or powder. Gum dust is marketed separately.

Gum tragacanth and other gums of this class are valued differently from gum arabic for they have different uses, but freedom from earthy matter or other impurities is equally important (*see* Chapter III).

Industrial and Other Uses:—The uses of gums by man go back to the earliest times. From time immemorial primitive peoples have used those gums that occur in their area and which happen to be palatable for food, eating or sucking the gums as collected from the trees in the wild state. Many natural gums are sweetish in taste and not at all unpleasant, although some may be astringent or bitter. One of the main uses of gums by man is still as food, for the bulk of the gum that is imported is used in the confectionery trades. It is interesting to recall that during the second world war special booklets were prepared for airmen operating in certain theatres of war indicating how to make the best use of local resources for food, in the event of being shot down or making a forced landing in an uninhabited or sparsely populated country. In these, the possible value of the gums that might be found was stressed. As food most gums are quite wholesome assuming they are not taken to excess, and may in part take the place of the more usual carbohydrate foods. Actually short and long term feeding experiments with rabbits have shown that gum arabic and starch are equally effective in glycogen and fat formation (IWATA HISAYOSHI). Gums are regularly eaten by local inhabitants in many parts of the world, especially India, where they are commonly marketed in the bazaars and used in the preparation of "laddu" and various other kinds of sweetmeat, also for peppermints, sherbets and syrups. It is often chewed after meals. Another common use for gums in India, especially the poorer grade gums is for mixing in whitewash for walls. It may also be mixed with mortar in housebuilding operations (CAIUS and RADHA 1939).

In Australia, wattle gum is well known as a food of the blacks, being eaten especially with fish. According to MAIDEN (1890) it was also "the particular delight of small Sydney boys. They soak it in water, add sugar, call the preparation 'gum jelly,' and consider it exceedingly toothsome." In this connection the following extract from the Sydney Morning Herald of the 24th March 1891 is of interest.—"A little boy named Finch, who was lost on the 15th instant, was recovered yesterday by a black tracker engaged from Benalla. The child seemed thin, but was otherwise not much the worse for his eight days in the bush. He was found 10 miles from home, and said he had lived on wattle gum. Over 400 people had been in search of the boy all the week, and were just on the point of abandoning their pursuit as useless."

Gum arabic—and possibly some of the other North African Acacia gums—is known to have been used by the Egyptians quite 2,000 years ago in preparing their colours for painting and to have been an article of trade at that time. Today, gum arabic is still an important ingredient in the manufacture of certain fine water colours and is regularly used for this purpose. Without it, colours would readily rub off or smudge.

The best grades of gum arabic are used in medicine and in confectionery. Gum arabic possesses little medicinal action in itself although locally applied it is soothing to irritated or inflamed mucous membranes. Its principal use is as a vehicle for more powerful remedies and it is an important constituent in a large number of proprietory medicines. It is used as a binding agent in the preparation of rouge and face powder compacts and in perfumed cachous and lozenges, also in fumigating pastilles. It is an ingredient of glycerine soap creams and of complexion milks and creams, also of hair curling powders, moustache pomades and the kohol eye cosmetics.

Medicinally, gum arabic (or gum Acacia) is used as a demulcent and as a colloid. "It is administered in mixtures, cough syrups and tinctures, in the form of mucilage, in various jujubes and pastilles and as Injectio Sodii Chloridi et Acaciæ for intravenous injection. The colloid content and osmotic pressure of this injection are equal to those of the blood. It does not leave the blood vessels and is preferable, therefore, to saline solution alone. In cases of severe hæmorrhage from abdominal wounds and arteries, it has great value in raising and maintaining the blood pressure. It is also used in cases of shock where the blood pressure has fallen dangerously low. In dispensing, acacia is used as a pill excipient, either alone or as Pulvis Acaciæ Compositus which is a mixture of powdered acacia and powdered tragacanth in equal parts, and as a suspending agent in mixtures containing insoluble powders, but it is unsuitable with bismuth salts, with which it may form flaky masses. Powdered acacia is also used for the emulsification of fixed and volatile oils." (Br. Pharm. Codex 1934, 4).

Other uses for good quality gum arabic (or similar gum) are in the "finishing" (imparting lustre) of silk and crêpe and of textiles and paper, also in calico printing and in certain dyeing processes. It is also used in the paste and polish industries, in clearing liqueurs and in lithographic work, In the manufacture of inks of various kinds and matches the poorer qualities are often used, for the darker colour of the lower grade gums is of little consequence when used for such purposes, provided they possess the necessary adhesive properties. Only the best grades are suitable for pharmacy and confectionery, *i.e.* those that are more or less colourless, odourless and tasteless. One of the more recent uses for gum arabic and gums of the gum arabic class is as a "body builder" in the transparent finishes used for artificial silk or rayon.

It has been estimated that quite half the gum arabic imported into Britain is used in the confectionery trades and the same may apply to other countries. In the last two decades there has been a great rise in popularity in sweets or candies of the gum type, and of pastilles consisting largely of gum arabic. They are often preferred to the "boiled sweets" that held greater prominence in earlier days. Gum arabic and other gums have also been used for imparting smoothness to ice cream and in making syrups. Other prepared foods in which gums may be used include fruit syrups, fruit spreads, jellies, salad dressings, mayonnaise, pickles, sauces, chutneys, flavour emulsions, and "egg substitute" preparations.

In the manufacture of various classes of stationery, especially envelopes, labels, etc., gum arabic is much used, although other adhesives may be employed. Various grades of gum may be used but the lighter coloured ones are usually preferred, especially for the finer classes of stationery. Another use is for postage stamps. Glycerine may be added to the gum to prevent it cracking. Among the minor uses of gum arabic is the preparation of certain culture media in laboratory and bacteriological work.

The so-called insoluble gums or gums of the tragacanth class have many uses similar to those of gum arabic but possess others that are quite distinct. However, the main uses of gum tragacanth and similar gums are in calico printing and in pharmacy. In calico printing it acts as a thickening agent in the preparation of the colour mixtures used. "In this industry coloured pastes of suitable consistence are printed on the fabrics, and it is most important that the colours should not run, but should produce patterns with sharply defined edges. Great skill and experience are required in preparing such pastes. It is stated that in giving consistence to a liquid, with equal parts of water, 10 parts of gum tragacanth are equivalent to 20 parts of starch, or 22 parts of wheat flour, or 130 to 140 parts of "calcined" starch. It is important that the gum used should not affect the brightness of delicate colours, nor weaken the mordants by its acidity or in other ways; it is also desirable that the thickening agent should not penetrate too far into the fabric. In printing dark colours, the smaller the quantity of thickening agent that will give the necessary consistence, the less the colour is lightened by dilution." (Bull. Imp. Inst. 6:30).

Gum tragacanth and the allied vegetable gums are used in various ways in the textile industry in addition to calico printing. They are a common constituent in the mixtures used in the sizing and dressing of yarns, often in combination with starch, china clay and certain mineral salts. They may be employed in the mixtures used for polishing sewing threads in combination with wax and other substances, and in rope and twine finishing. They may also be employed in mixtures of waterproofing and for stiffening felt hats and other felt goods. In certain classes of laundry work and in leather dressing and finishing they have uses. This class of gum is used in the paper trade for sizing various kinds of paper, including imitation art paper, and for incorporation in the colour pastes used for some wall papers.

The medicinal use of tragacanth is mainly for temporarily suspending insoluble powders, such as resins or heavy insoluble powders in fluid mixtures. It is also used to emulsify certain oils and to impart the necessary firmness to pill masses. Frequently it is used in conjunction with gum arabic. The glycerine toilet creams and jellies, so much used, commonly have gum tragacanth as a constituent. It enters into the composition of numerous other toilet preparations such as emollient skin creams and lotions, nail polishes, shaving lotions, toilet milks, dental creams, depilatories and permanent wave fixers. As a binding agent it may be used in much the same way as gum arabic and is the basis of greaseless creams and hair fixatives now so popular. Other uses for tragacanth are for supporting dentures and as a basis for lubricants for surgical instruments and for catheters. In recent years Karaya gum (*Sterculia urens*), which is similar in many respects to tragacanth but cheaper, has been successfully used as a spreader in nicotine sprays used as insecticides.

Karaya gum, or Indian tragacanth, is a gum similar to ordinary tragacanth and commonly used as a substitute for it but its extensive use in industry is of comparatively recent date. It is now freely used in the textile, food, cosmetic and other industries. For some purposes it is regarded as superior to tragacanth and has the attraction to manufacturers of being cheaper in price. Like tragacanth it swells with water to form a gel rather than a mucilage and needs to be finely ground. A solubilizing treatment is often applied to it before use in industry. This consists of boiling under slight pressure or boiling with small quantities of oxidising agents. For textile finishing it may be completely decolorised by bleaching agents. The main use of the gum is as a thickening agent for printing pastes in the textile industry. It is sold to the textile industry either in the powdered form or in a solubilized form as a powder, paste or solution (MANTELL, 1947).

Another gum of the tragacanth class whose uses have extended in recent years is Carob seed gum, also called Locust bean gum or Locust kernel gum (*see* page 44). Like Indian Karaya gum it is now much used for many of the purposes for which tragacanth alone was formerly used. Its main use is probably in the textile industry for printing pastes and for sizing and finishing. The gum has unusual thickening power. Its good binding power, transparency, and flexibility render it well suited for finishing white and printed fabrics. In printing its working qualities are similar to tragacanth (MANTELL, 1947). In addition to pharmaceutical purposes the gum finds use in the food, rubber, tanning and other industries (*see* page 44).

Chapter II

GUM ARABIC AND OTHER ACACIA GUMS

The Sudan

The History and Present Importance of the Gum Trade:— For many years now the normal annual export of gum arabic from the Anglo-Egyptian Sudan has exceeded 20,000 tons, and as far back as 1879 it was in excess of 7,000 tons. Actually, Sudan gum arabic has been an article of commerce for some two thousand years. Originally it was sent to Arabian ports and then to Europe, hence the name "gum arabic". In the middle ages it often went first to Turkish ports and so acquired the name "Turkey gum" that was once commonly used for it in the trade. It is believed (BLUNT) that a certain amount of the Sudan gum also found its way to Bombay to be re-exported as "East India gum."

Gradually the gum came to be exported direct to European and American markets. This took place at first from the Red Sea ports. During the Mahdia however (the period of the rebellion of the MADHI, 1881-1899), the trade was badly disrupted and practically ceased. This resulted in a great shortage of gum arabic and caused users to look elsewhere for supplies. The French developed the Senegal gum trade as a result and Indian gums were at a premium, but unfortunately their mixed and consequently inferior nature was against them.

After the Mahdia and with the completion of the railway to Khartoum, Sudan gum was exported mainly through Egypt. However, with the construction of the railway between the Nile and the Red Sea in 1906, Sudan gum gradually came to be exported almost entirely from Port Sudan and not through Egypt. The extension of the railway to El Obeid in 1912 resulted in a sharp increase in the exports of gum from Port Sudan. It also reduced the importance of Khartoum and Omdurman as centres in the gum trade and El Obeid became the all important centre.

Improved rail and export facilities have not been the only reasons for the steady increase and the healthy growth of the Sudan gum trade. The improved marketing conditions and regularized auction markets inaugurated and run by the Government with such success, have done much to improve and extend the trade. For with the present marketing system the Arabs are assured of fair play and of getting good and fair value for their gum. The fixed royalty rate, which assists merchants to fix prices in making contracts, is another contributory cause.

Sudan gum arabic is now exported direct to numerous consuming countries. For the five years preceding the second world war the average annual export (in long tons) was as follows:—

United Kingdom	5155	Canada	206
United States	3750	Egypt	201
France	2499	Denmark	185
Germany	2400	Brazil	126
Belgium	1506	Br. India	123
Italy	1029	Argentine	103
Japan	9911	Poland (Danzig)	92
Netherlands	817	Roumania	87
Australia	590	Greece	77
Sweden	480	Norway	70
Spain	290	New Zealand	64
China	224	Other Countries	456
TOTAL	21689		

With some of the major importing countries a certain proportion of the total import may be re-exported and not consumed locally. For example, about 20% of the total quantity imported by the United Kingdom has been re-exported in some years, exports going to the U.S.A., Germany, Poland, Holland, Belgium, France, Italy, Brazil and Japan. As London is regarded as the leading gum market of the world this is not surprising.

Distribution and Description of Gum Yielding Species:—Although some two dozen or more species of *Acacia* are known to occur in the Sudan the commercial gum is obtained almost entirely from one species—*Acacia senegal* (syn. *A. verek*). A small amount of gum, that known as "tahl" gum, is obtained from *Acacia seyal*. This limitation of the botanical sources of the gum doubtless accounts, in part at least, for the uniformity of Sudan gum arabic, and is a contrast from other gum producing countries, notably India, where it is common for the gum of a number of different species to be collected indescriminately and mixed.

Acacia senegal is the characteristic species in the drier parts of the Anglo-Egyptian Sudan and the northern Sahara and is to be found throughout the vast area from Senegal to the Red Sea and on to eastern India. It extends southwards also to northern Nigeria, Uganda, Kenya, Tanganyika and southern Africa. In India it is found chiefly in Sind and Ajmere. (A. H. W. WEIR 1930). In the Sudan the tree exists both wild and cultivated where it is chiefly found on the sandy gozes or hills but it also grows on the cotton soil. In the latter habitat it is not found pure, being usually mixed with other Acacias. The country is usually undulating, the hills being sandy, while the depressions consist of cotton soil, where water usually stands during the rains. The largest pure stands of *Acacia senegal* occur in the Kordofan province north of Khor Abu Habl. It is said that "the railway to El Obeid may be looked upon as the approximate southern boundary of the large pure stands of *Acacia senegal* which form an almost uninterrupted belt across Kordofan into Darfur. South of the railway the sandy soil begins to give place to the cotton soil which covers thousands of square miles in the Sudan, and with it *Acacia mellifera* tends to become the commonest species until, with the larger rainfall further south, *Acacia seyal* becomes more plentiful (D. W. MALCOLM 1936).

"Hashab" is the common Arabic name used for it in the eastern Sudan and elsewhere, although it may be applied to other Acacias as well. Further west and in Senegal it is perhaps best known by the name of "verek."

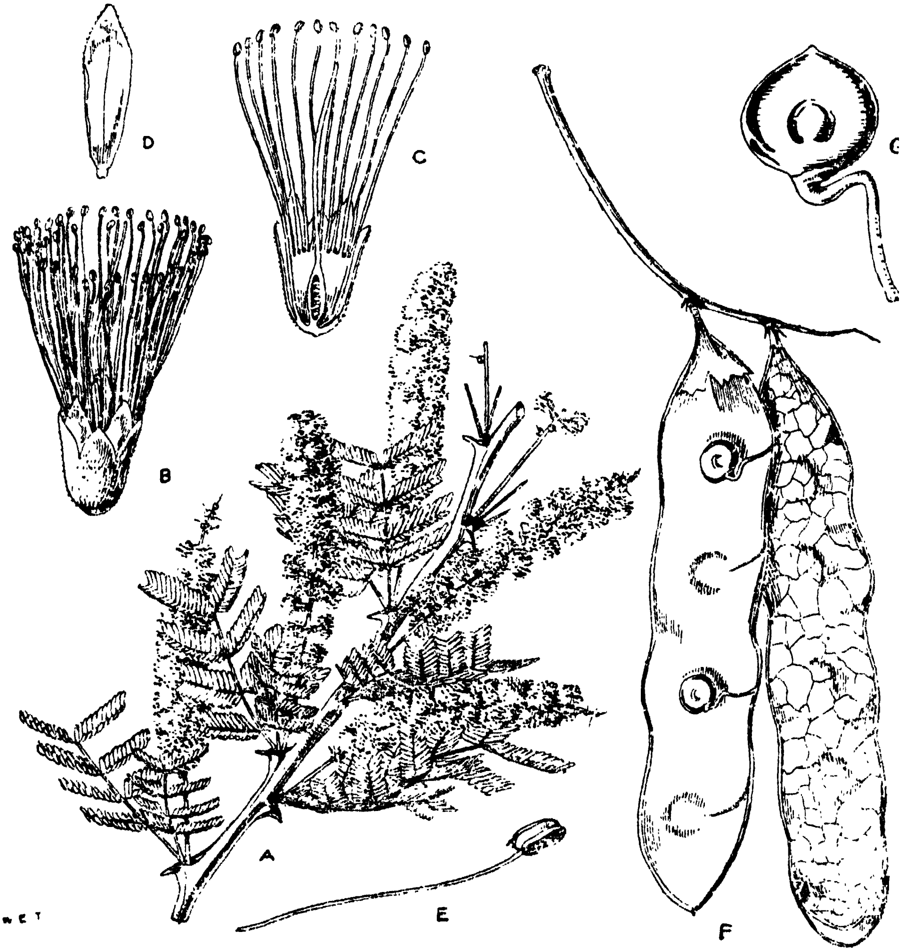


FIGURE 2.—**Acacia senegal** Willd. The source of Sudan gum arabic (A, flowering branch; B, flower; C, longitudinal section of flower; D, calyx-lobe; E, stamen; F, mature pods; G. seed; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

The tree is usually from 15-20 feet in height and often branched from near the ground. In its young stages it may appear as a dense thorny shrub. Sometimes, as in an adverse environment, it remains stunted and shrubby. It generally occurs scattered but may also form dense thickets. The branches fork repeatedly and in mature trees commonly form a flat topped crown. The trunk may vary in diameter up to about 1 foot, while its bark is light in colour (greyish white) although in old trees, growing in the open, it may be dark. The bark is very thin and if scratched with the nail shows the bright green cambium layer just below the surface, the slash being mottled red (H. V. Lely 1925).

The light feathery leaves (bipinnate) seldom exceed 3 inches in length and are bluish green in colour, paler on the under surface. Each leaf has from 3-6 pairs of pinnæ or "limbs" attached to the main stalk and each of these bears some 6-12 pairs of leaflets (sometimes more), these being 3½-5 mm. in length and about 1 mm. wide.

Powerful hooked thorns (3-5 mm. long) with enlarged bases occur at the nodes of the branches, usually in threes. As these are very sharp and point in both a forward and a backward direction they constitute a formidable armament for the plant, prone to tear the flesh of man or beast if not approached with care.

The flowers are borne in short dense bunches (spikes) in the angles or axils of the leaves, usually two such bunches in each axil. They are creamy white in colour with a pleasant fragrance, drying to yellow. Each flower has a 5-lobed calyx, deeply lobed, 5 petals and a mass of short stamens. The pistil or female part of the flower is inconspicuous.

A notable feature of the tree is the relatively broad, flat, membraneous seed pods which it bears. These vary from 1½-4 inches in length according to the number of seeds they contain and are about 1 inch in width. In colour they are grey or tawny, often with darker patches, and bear prominent veins. They are pubescent or downy when young. When mature they may remain on the tree for some months after the seeds have ripened or after the leaves have fallen.

In the Sudan "the life of the tree would appear to be between twenty-five and thirty years, and less in some places. At the later age it is attacked by numerous insects and finally finished off by white ants. It is attacked through wounds by longicorn beetles and borers. Locusts (*Acridium melanorhodon*) defoliate large areas now and again. Goats and camels are probably its greatest enemies. Fires kill off seedlings and damage the trees very considerably" (Blunt). A good deal of damage is also caused to trees through natives cutting off large branches to use as fences or barricades for live stock on account of their thorny nature.

Acacia seyal has long been exploited for gum in the Sudan and elsewhere, although the product is markedly inferior to that of *Acacia senegal.* It is the source of the "tahl" gum of the Sudan, known also as "talca," "talha," "talki" or "suakim" gum. In some years this type of gum has constituted about 10% of the total quantity exported. The tree has a wide distribution which is not unlike that of *A. senegal* for it occurs from Senegal to the Red Sea and also in Arabia. It is common in many other parts of Africa, especially north of the Equator from 10–12°. It occurs also in east and southern Africa. In the southern and western Sudan it is one of the common species in the savannah, and often occurs as pure forest over quite large acreas of country (H. V. Lely 1922). Frequently it grows in groups or patches sometimes of considerable size, in the areas inhabited by *A. senegal.* Tahl gum is characteristic of the Blue Nile region.

Generally *Acacia seyal* occurs as a small tree 15–30 feet high with an umbrella shaped or flat topped crown. A characteristic feature of the tree is its rust coloured powdery bark. A variety (var. *fistula*) with whitish bark exists. Large straight spines, in pairs, from 1–2 inches long, occur on the branches, and smaller curved thorns are present near the tips of the branches. The dark green, bipinnate leaves are 2–3 inches long and are borne, usually in threes, in the angle of each pair of thorns. During the dry season they may fall from the tree. The flowers are in yellow balls about ½ inch in diameter on short stalks in the axils of the leaves. Flowering is often very profuse, taking place with the formation of new leaves, and may cause the tree to look quite yellow from a distance. The light brown, slightly curved pods, 3–5 inches long are conspicuous and contain 6–10 seeds. In some parts of Africa the tree affords an important source of food for live stock, natives driving their animals to where it is common and lopping off branches for them, when both leaves and young pods are eaten. (J. M. DALZIEL 1937).

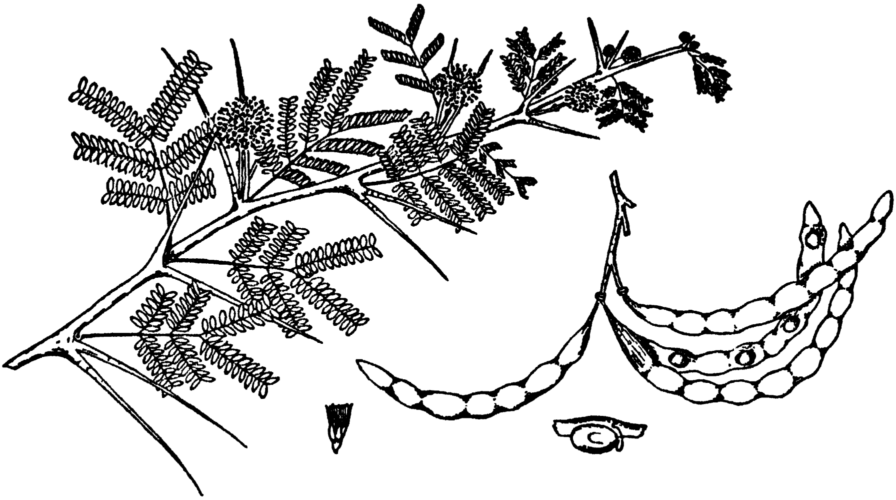


FIGURE 3.—**Acacia seyal** Del. Widespread in North Africa and the source of tahl gum.

Usually trees of this species are not tapped, the gum being collected from natural exudations only. According to some observers, tapping does not induce gum production in *A. seyal.*

Where "tahl" (*A. seyal*) and "hashab" (*A. senegal*) occur together or mixed, as frequently happens in the Sudan, it would appear that "the former should not be cut out and only under certain conditions thinned, as it acts as a nurse to the "hashab" and tends to resist a dense growth of grass thereby assisting in fire protection" (Ann. Rpt. Sudan Dept. Agric. & Forests, 1928, 75).

The following are other species of *Acacia* that occur in the Sudan and which are known to exude gum. It is probable however, that very little of the gum of these species is collected or finds its way to the export markets mixed with "tahl" or "hashab":—*A. abyssinica*: *A. albida*: *A. arabica*: *A. campylacantha*: *A. thunbergiana*: *A. drepanolobium*: *A. farnesiana*: *A. flava*: *A. kirkii*: *A. laeta*: *A. orfota*: *A. sieberiana*: *A. spirocarpa*: *A. stenocarpa.*

Collection and Tapping:—The tapping of *Acacia senegal* for gum as practised by Arabs, is probably unique, and is different from the methods employed for the collection of other plant exudations such as the various rubbers, chickle, balata, etc., balsams, resins or other gums. In the early days all the gum arabic marketed was derived as a result of spontaneous exudation, the practice of tapping being said to have originated about 50 years ago.

In tapping, the only implement used is a small axe with the head (locally made), about 1½ inches wide and 6 inches long, the wooden handle being 2–2½ feet in length. The blade is lightly driven under the bark of the trunk, any low obstructing branches being first cut away if necessary, and then pulled back causing the bark to break and leave two broken ends. These ends are then pulled in turn, one up and the other down the stem, causing long strips of bark about 1½ inches wide to be torn from the tree. Each season the bark is torn in this way from a different part of the stem thus gradually working round the tree. Gum forms along the strip or wound in due course, not along its whole length, but only in places. The length of time required for the tears to form is dependent on the weather, hot dry weather accelerating, and cold or wet conditions retarding it. With favourable weather there may be sufficient gum formed to make collection worth while in 3 weeks, but with unfavourable weather as long a period as 2 months may elapse. Under average conditions, a single tapper may tap about 100 trees in a day (BLUNT). This method of tapping, by removing a strip of bark, is in effect very efficient and causes a large or long wound with a minimum of effort. It is noteworthy, however, that it can only be applied to those Acacias, of which *A. senegal* happens to be one, that have the thin fibrous type of bark and not to the fleshy barked species.

In collecting the tears of gum, work in which women may assist although men only do the tapping, the dry gum is simply pulled off with the fingers and placed in a skin bag. A small spear may be used to dislodge the tears high up out of reach. After the first collection has been carried out other collections are made from the tree about every 10 days for the rest of the tapping season, for the gum continues to be formed from the wound.

The gum season in the Sudan corresponds with the dry season and is approximately from October to May or June of the following year. There is a certain amount of variation from district to district. During the rest of the year, when rain occurs and the trees are green and in full leaf, no gum is formed. As soon as the dry season is under way and the leaves being to wither and fall from the trees the time is propitious for tapping.

If the gum garden ("geneina") or tapping area is some distance away the tapper or collector may use a camel or donkey and take with him water and food for an absence of several days. Gum may be collected either from gum gardens (fields that have been allowed to revert to Acacia or have been sown), which are private property, or from wild trees. From the former the gum is termed "hashab geneina" (garden gum) and from the latter "hashab wady" (wild gum).

Water supply is one of the main problems in many of the gum areas. which are naturally waterless in the dry season. This water shortage often considerably restricts the area that the natives can cover in collecting gum. However, work has now been carried out by the Sudan Government to alleviate this. This includes the construction of deep bore wells in some areas and of dams, earth tanks and stone and cement pits in hilly districts. Another factor which has increased gum production has been the closer supervision of the work of the Gum Boards which has meant an increased number of tappers being able to harvest the crop of registered gardens on equitable terms (Ann. Rpt. Sudan Dept. Agric. & Forests 1932, 64). The extent to which gum is collected is always dependent to some extent on the seasonal prosperity of the natives. If food or other crops have been poor and money is needed to buy food, more gum is likely to be collected. On the other hand if there is plenty of food or money available gum collection may suffer, particularly in the more remote areas. This is not surprising when it is remembered that tapping and collecting are arduous tasks and rendered the more unpleasant by the thorny nature of the trees and their low branching habit. The success or failure of the "durra" crop (Sorghum—the principal food crop of the Sudan) has a more direct effect on the gum exports than anything else. A good "durra" crop foreshadows smaller gum supplies during the following dry season.

Marketing, Bleaching and Grading:—After gathering the gum from the trees the Arab collector usually takes it to his village and may store it in his dwelling until he has sufficient to take to market, or to sell to a buyer with camels who transports it to market. At one time gum was stored by burying—also practised by collectors in Senegal (DE CORDEMOY). This leads to contamination with sand or earth, but the fact that all gum is now examined before purchase in the Sudan has discouraged this harmful practice. If the collector learns that prices are low or is busy with other work he may defer selling his gum. Camel owning tribes who go long distances to collect gum may transport it direct to the market.

At one time in the Sudan there were no regular gum markets and traders went into the country with scales and bought the gum from the Arabs. It is said "The trader would put his leg on one side of the scales, the gum being placed on the other scale. A leg was considered to weigh 10 rottles (1 rottle = 450 gms. or .99 lbs.), and with pressure could be made to equal 100 rottles or more" (BLUNT)! Early in the present century, however, gum markets were established at various centres. Buyers or brokers would barter with the Arabs for their gum, but the Arab did not always come out well in the deal. In 1922 a system of auctioning the gum was introduced at one market (auctioned by the Government and under Government control). This proved so satisfactory to all concerned, both buyer and seller, that the method was soon introduced to other markets and has continued to operate satisfactorily ever since.

The method has been described as follows:—"The Arab on entry into the gum-market is given a ticket showing the number of the lot in which he is to place his gum. The Forest guard at the gate also writes on a form the number of the lot and the Arab's name. Every skin of gum is then opened and the merchants examine the gum *in situ*. At 11:15 a.m. the gates of the gum-market close, and the Government clerk, with the form in his hand, commences to auction the gum, starting with lot 1. Bidding is by piastre for a kantar. When bidding has ceased the Arab is asked if he will sell, and, if he accepts, the price accepted is written on his ticket, and on the auctioneer's form the clerk writes the name of the purchasing merchant and the price accepted. After the auctioning is finished the gum is transferred into the merchant's sacks and weighed by the Government clerks in front of the purchasing merchant and the Arab. The price accepted and the total weight of each lot or individual's amount are entered on a weight-note. The clerks then make the calculations, showing the amount of money each Arab is to receive, and a copy of this weight is given to the merchant, who pays the Arab in the gum-market. The Arab, if he thinks that he has not been paid his full money, can always have it checked at the office. It will be seen how the Arab is nursed right through the market. The merchants are pleased, as they are dealing direct with the Arab in an open market, and the auctioneering never takes more than an hour, whereas in olden days they had to stand in the market from 9 a.m. till 2 p.m. After the gum has been weighed it is taken out of the market to the merchants' sheds, where it is placed in double sacks and ultimately sent to Port Sudan" (BLUNT).

The best grades of Sudan gum arabic are hand picked, which ensures even colour and freedom from fragments of bark and other impurities. This work is commonly done by women seated on the ground, each with a sack of gum at hand and a wide tray on which to spread out small quantities of gum at a time, to pick it over.

Sun bleaching is carried out by carefully spreading tears on sheets in the sun for 3 weeks or longer. This gives a uniform light colour, or frosted appearance and easy friability, enhancing its market, if not its intrinsic value. This is due to the development of numerous small fissures on the surface of each fragment. Bleaching is mainly carried out at El Obeid and Omdurman and in the hot dry season when temperatures are very high. At night if conditions get cool the gum may be moved indoors and covered with several layers of cloth to "keep it warm." Rain, even the smallest shower, if unforeseen, may cause much damage to the gum as may be imagined (MALCOLM).

Sudan gum arabic may be exported in the natural state (as collected), cleaned and sifted, bleached or as dust.

The methods of grading with gum arabic have varied much from time to time to meet the demands of the different consuming trades. At one period a good deal of grading was done at Trieste where great pains were taken to ensure uniformity and a large number of different grades established, but Trieste has long since ceased to be an important centre. There is no grading of this kind carried out in the Sudan. The standard ordinary Sudan or Kordofan gums are generally referred to as "sorts." Good quality, bleached gum fetches the highest prices on the London markets. It has stood at 90–95 shillings per hundredweight when "Kordofan cleaned sorts" have fetched 40–45 shillings and "tahl" gum 20 shillings.

Cultivation:—Government experimental gum plantations have been established in the Sudan for many years and have yielded interesting statistics, particularly with regard to the rate of growth of the trees, yield of gum per unit area and per tree at different ages and with different spacing, also on costs of collection, where hired labour is used etc. (*see* BLUNT'S monograph). At one plantation it was found the average yield of gum per tree in a season was .14 of a rottle (1 rottle = .99 lb.). Some trees gave as much as .9 of a rottle, others yielded very little. The best plots averaged about 60 rottles of gum per feddan per season. This works out at about 60 lbs. per acre, a low yield compared with most economic plant products.

The fact that good cultural treatment, manuring, etc., depresses rather than increases the gum yield and the probable reasons for this have already been pointed out (Chapter I).

Trees yield gum freely if tapped 6–7 years old, but tapping when very young is likely to lead to the early death of the trees. The largest trees do not necessarily give the most gum and after a certain age, as they approach the latter part of their 25–30 year life span, they yield less and less.

Acacia senegal is easily raised from seed although like most hard Acacia seeds, it is slow in germinating. The seedling has to struggle in its early stages against grass and various insect and other pests as well as the possibility of insufficient rain at a critical period. The Arabs usually rely on natural regeneration for the establishment of their gum gardens. Trees do not seed freely every year and generally a good seed year means a poor gum year. In one area the trees may be covered with seed pods, while those in another may have hardly any, due perhaps to local differences in environment or climate and rainfall.

French West Africa

Past and Present Extent of the Senegal Gum Trade:—Next in importance to the Anglo-Egyptian Sudan among the gum exporting countries of the world is French West Africa, although the total export of gum may only be about a quarter of that of the Anglo-Egyptian Sudan. Prior to the second world war, which of course completely disrupted the trade, the annual export of gum from these French territories was from 3–6,000 tons as against over 20,000 for the Sudan, (figures being actually 1933, 4,637 tons: 1934, 3,934 tons: 1935, 4,769 tons: 1936, 5,338 tons). In these four years almost the entire export was to France, other countries receiving only 610, 579, 292 and 992 tons during this four year period. These other countries included the United Kingdom, Belgium and Germany. Bordeaux has long been an important centre for the trade in French gum arabic.

In French West Africa Senegal, Mauretania and parts of the French Sudan all produce gum arabic, but Senegal is the most important producer. The Senegal gum arabic industry, like that of the Nile region, is of long standing and has been through may vicissitudes. The gum was known in European commerce as early as the 17th century. At the time, the trade was confined to France, but the gum gradually came to be sold in other European countries. The trade finally reached its zenith in the latter part of the 19th century at a period coinciding with the Madhia or Sudanese rebellion, for this caused a cessation of gum supplies from the Nile, resulting in a shortage of world supplies and keen prices. This acted as a stimulus to the Senegal industry. A description of the early development of the Senegal gum trade has been given by DE CORDEMOY (1911) and other French writers, while good accounts of the industry in more recent times have been supplied by CHEVALIER.

Main Gum Yielding Regions:—The French West African gum industry is similar in many respects to that of the Nile region and shares many of the same difficulties. An important point of similarity is that gum is obtained primarily from the same species of *Acacia, viz. Acacia senegal,* the tree being equally widespread and prevalent in many parts of French West Africa as it is in the Anglo-Egyptian Sudan. Other similar features are:—the remoteness of some of the good gum yielding districts, their sparse population, the shortage of drinking water in the dry season and the fact that gum may be obtained from both tapped and untapped trees. The same reluctance to collect gum in periods of prosperity also applies. Some of the best gum collecting districts, where *Acacia senegal* is very prevalent, lie along the north side of the Senegal river and the tribes that collect the gum include the Maures, Braknas, Trarzas and Douaich (DE CORDEMOY). Unlike the Nile region, there are two gum collecting seasons, corresponding to two instead of one dry season. The one lasts from December to February ("petite traite"), and the other from April to July ("grande traite"). The latter is the more important and yields the most gum, which is also of better quality and in larger fragments.

Gum forms soon after the cessation of the rains and its production is believed to be stimulated by the hot drying wind (Harmattan) that is characteristic of the West African region. The effect of the wind may be to cause unequal desiccation of the bark or the trunks of the trees, already turgid after heavy rains, and so cause cracking and the consequent exudation of gum. As in the Nile region tapping has not always been practised and is a development of more recent years. Indescriminate tapping of very young trees sometimes leads to their destruction.

Classes of Gum:—After collection most of the gum finds its way to the various centres and trading posts on the Senegal river, Medine being one of the more important of these, and is then transported down the river to St. Louis for export by sea. There are three main qualities of crude Senegal gum, but these may be subsequently graded into several different grades. These three main qualities are described as follows:—

Gomme du bas du fleuve.—Produced in the district of Podor in Lower Senegal and the best of the Senegal gums. It occurs in large round or thick vermiform tears. The colour varies from almost white, through a pale cherry to brownish yellow.

Gomme du haut du fleuve.—Obtained in Fouhlah-land, Guidimaka and Bambouk, all in Upper Senegal. It ranks second in price and occurs in rounded, vermiform or branched tears, smaller in size than the first quality and on the whole darker in colour.

Gomme friable, Salabreda, or Sadra beida.—This is the poorest quality of Senegal gum. It consists of small grains and vermiform tears, the former brown and the latter more lightly coloured. There is a tendency for it to cohere in masses (Bull. Imp. Inst. 6:44-5).

The quantity of gum produced in the first of these three classes in normal years is very much greater than that in the other two, and may be as much as 100 times as great as the amount of salabreda.

What grading has been done with Senegal gum has been mainly carried out at Bordeaux and not in Senegal, much care being devoted to hand picking. "The gum is first sorted into "whole" and "broken" tears. The "whole" tears are then picked according to colour, when the following grades result.—*Gomme blanche.* This variety is almost colourless. The individual tears are globular, and vary in diameter from 1 to 4 cms. (0.4 to 1.5 inches). The surfaces are covered with a network of minute marks, due to the drying of the gum, but the interior portions are glassy and transparent.—*Gomme petite blanche.* This grade resembles the foregoing, but the tears are smaller, varying from 0.5 to 1.5 cms. (0.2 to 0.6 inch) in diameter.—*Gomme blonde,* resembling Gomme blanche in size but rather darker.—*Gomme petite blonde,* resembling Gomme petite blanche in size but a little darker in colour.—*Gomme vermicelle,* including vermiform or branched tears, varying in colour from almost white to pale yellow.—*Gomme fabrique* consisting of tears, which on account of unusual shape or dark colour are unsuitable for the foregoing groups.

The broken gum is sorted by sifting, and gives the following principal grades; these are each fairly uniform in size, but the colour varies from pale yellow to deep brown:—*Gomme gros grabeaux, Gomme moyens grabeaux, Gomme menus grabeaux, Gomme poussière grabeaux."* (Bull. Imp. Inst. 6:46).

The average class of commercial gum arabic from French West Africa is of a rather darker colour, more yellow or reddish, than the average Sudan gum arabic. It is also not quite so clean. The tears are usually larger in size and less brittle than the tears of Sudan gum. The French West African gum is believed to often give solutions of greater viscosity than the Sudanese but to be less adhesive (MANTELL, 1947).

Nigeria

Limited Extent of Export Trade:—The gum arabic export trade of Nigeria differs from that of the Anglo-Egyptian Sudan and of French West Africa by being of much more recent origin and by having been, so far, of very much smaller dimensions. The export of gum from Nigeria in appreciable quantities more or less dates from the present century. The quantity exported in a year has never exceeded a few hundred tons whereas that of the other two territories referred to runs into thousands of tons. In the years immediately preceding the second world war, the annual export varied from about 400-700 tons with an average of 521 tons. In the early years of the present century the trade varied from approximately 150–300 tons. It is thus obvious that the trade has not increased to a very great extent over this 30–40 year period.

Gum Producing Areas:—It is the northern provinces of Nigeria that border on the southern Sudan that constitute the main gum producing areas, particularly the province of Bornu, which adjoins Lake Chad.

The best gum in Nigeria is obtained from *Acacia senegal,* the same species that is the basis of the gum industries of the Nile region and Senegal. However, it would appear that in the Sudan there is a more general distribution of the tree and it occurs over a much wider area than is the case in Nigeria, where its distribution is more patchy. In an account of gum arabic in Bornu (A. H. W. Weir 1930), it is pointed out that the trees occur in scattered groups or patches of varying size and density and as scattered individual trees in company with other species, and that few of these patches exceed 3–4 miles in extent. Between them are large tracts of grass or cultivated land. It is believed that trees of *Acacia senegal,* or "konkol" as they are termed, were more prevalent at one time than they are now in many districts, much destruction having taken place through shifting cultivation on the part of the natives. The fact that the native population has also increased in recent decades has added to the destruction. The tree favours the light sandy soils which also happen to be the ones favoured for crops of "gero" or bulrush millet (*Pennisetum spicatum*), a staple food. When burned the trees afford a good source of potash to the farmer. They are also raided for thorny branches for the construction of fences or barricades for livestock. Destruction of the tree therefore easily takes place, especially when no form of control exists. In Bornu the districts of Mobber, Geidam and Gubio are believed to have the greatest number of trees of *Acacia senegal.*

Collection:—In Nigeria gum has never been collected in the same regular and systematic manner that is the case in the eastern Sudan. In the main it has always been collected in a desultory manner by the native and often for sale on the local market where it eventually finds use as food—in sweetmeats and other comestibles. Reasons that have been given for this are that the average inhabitant is better off than is the average Sudani and that he is more occupied with other things such as his live stock, hides, etc., to bother about collecting gum. Furthermore, in the past very poor prices have been paid to the natives for gum by trading firms in Nigeria, so that the financial inducement to go out and collect gum has never been very great. The trading firms have often had very little real interest in gum and have only been prepared to buy when they have been able to procure supplies very cheaply.

Tapping Experiments:—Tapping or tearing off strips of bark to encourage increased gum production by the trees has never been practised by the natives, although experimental tapping has been carried out and efforts made to instruct local natives in the practice. Tapping experiments by Shaw and Weir gave on the whole favourable results, trees sometimes yielding ½ lb. gum. This does not compare unfavourably with the Sudan (Kordofan).

Kinds of Gum:—In the Northern or Hausa provinces of Nigeria three general classes of gum are recognised under the names of "Falli," "Marrua" and "Mumuye" (J. M. DALZIEL in Bull. Imp. Inst. **8**:352-365). Any white or nearly colourless gum may be called "Falli" and includes "Kolkol" gum (*Acacia senegal*). Tinted yellow or reddish gums are those termed "Marrua", while "Mumuye" is dark and in lumps or masses. "Marrua" is believed to be largely *Acacia seyal* (the "tahl" gum of the Nile region), and perhaps *A. xanthophloea,* while "Mumuye" is derived mainly from species of *Combretum.*

The best grades of Nigerian gum compare well with those from the Sudan and have been favourably reported on by users in the United Kingdom, but the poorer grades, and especially those that are mixed and contain fragments of dark coloured gum, are unable to compete with the standard Sudan gum. A sample of gum of *Acacia senegal* from tapped trees in Bornu Province forwarded by the Director of Forests to the Imperial Institute in 1933, and stated to represent the best type of gum obtainable in Bornu, was valued at 25s- to 27s-6d. per cwt. when Sudan gum (Kordofan natural) stood at 31s-6d. It was regarded as well suited for confectionery and probably for pharmaceutical purposes, although producing a slightly darker mucilage than Sudan gum. Good quality gum from Yola Province sent at the same time was also favourably reported on.

Other gums from Nigeria, specially collected from trees of known botanical identity, have been submitted for trade valuation (Bull. Imp. Inst. **32**:349-356). These included other species of *Acacia* and species belonging to genera such as *Albizzia, Anogeissus, Combretum, Isoberlinia, Khaya, Odina* and *Sclerocarya.* Out of a collection of some 65 samples only 6 were regarded by a gum broker, as worthy of consideration for export, the remainder being described as of poor quality and quite unsaleable in the United Kingdom. Frequently old discoloured gum was mixed with fresh, light coloured pieces and it was pointed out that "It may be taken as a guide that only bright looking gum of the palest colour, clean and free from bark and dirt is likely to find a market in Europe." The more promising samples of gum referred to, were yielded by *Acacia campylacantha* and *Acacia sieberiana,* both well known gum yielders and present in many other parts of Africa, including East Africa.

Fairly good quality gum has also been obtained from *Acacia laeta* in Northern Nigeria. A sample from Bornu Province, consisting mainly of amber coloured tears, with a few pink or reddish ones, was found to be well suited for confectionery purposes being valued in London at about 35/- with Kordofan gum at 38/- (Bull. Imp. Inst. **38**:297-9). A feature of the gum was its tendency to form gelatinous mucilages in comparatively weak solutions. *Acacia laeta* is a widespread species and occurs also in the Sudan, Abyssinia, Tanganyika and Kenya. *Acacia albida* is another species common in Nigeria and other parts of West Africa from which gum is sometimes collected.

East Africa

The Tanganyika Export Trade:—Acacia trees of one sort or another are common throughout East Africa, from Somaliland to Natal, and are the characteristic trees of very large areas of the open or savannah forest type of country. Gum may be collected by the natives from a large number of different species, generally for their own use as food, collection being done in a desultory or erratic fashion as the gum is required.

In Tanganyika, however, there is an established and organized export industry of Acacia gum or gum of the gum arabic type. It is only in comparatively recent years that this export industry has been developed and that Tanganyika gum has appeared in the United Kingdom gum markets. During the five years prior to the commencement of the second world war the export of gum from Tanganyika varied from 412 to 1040 tons per annum, with an average of 800 tons. By far the greater part of this export (average 662 tons), went to British India. Reasons for this are given later. For some years the export of gum arabic from Tanganyika has been greater than that from Nigeria, but immeasurably smaller than that from the Anglo-Egyptian Sudan and Senegal.

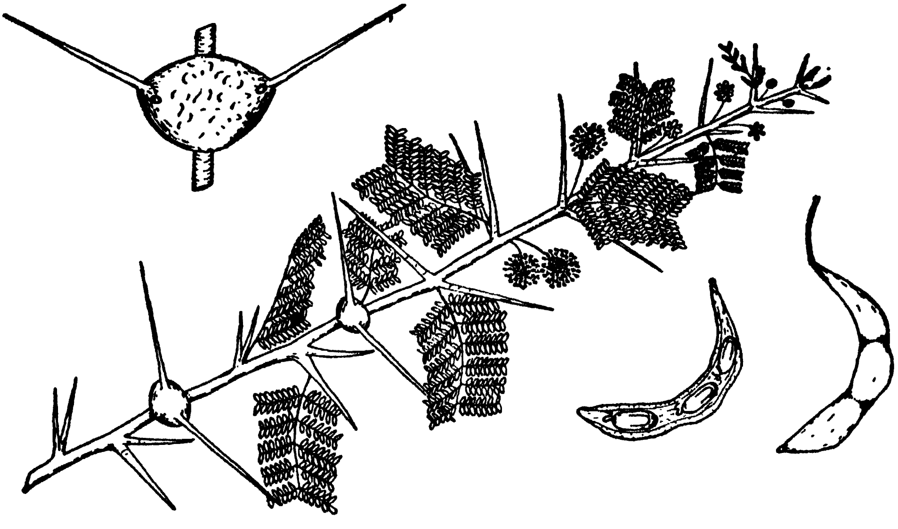


FIGURE 4.—**Acacia drepanolobium** Harms. Reputed to be the main source of East African gum arabic.

Species Yielding Gum:—Athough many species of *Acacia* occur in Tanganyika and at least 18 are known to yield gum, it is considered that the bulk of the gum that reaches the markets is derived from a few species only. Notable among these are *Acacia drepanolobium,* believed to be the most important gum yielding species in Tanganyika, and *Acacia senegal,* the source of Sudan gum arabic.

Acacia drepanolobium, known as "ilula lyapi", is common in the Shinyanga area of Tanganyika, which is an important gum yielding district, and said to resemble somewhat the Gedarif district of the Anglo-Egyptian

Sudan. It grows largely on the low lying black cotton soils and volcanic soils, especially areas subject to inundation, along with *Acacia fistula* and several other less important gum yielding species. The tree is often very prevalent. "Similar vegetation is met with in the river system draining into Smith Sound, where it is estimated that approximately a ninth of the annual gum exports are obtained" (D. W. MALCOLM 1936).

Acacia drepanolobium is one of the smaller Acacias common in many parts of north east and east tropical Africa, and occurs also in Kenya, Uganda and the Sudan. It is usually 10–12 feet in height with a trunk diameter of only a few inches and is very spiny. Ants of the genus *Cremastogaster* live in the galls or swollen bases of the spines. These may be as much as 2½ inches in length. The small hole that the ants make in each spine causes a whistling noise in the wind. This has given rise to the name "whistling thorn" used for the tree in Kenya. The bluish green leaves are small, seldom exceeding 2 inches in length and are shed during the dry season in many areas. The pale coloured flowers, in small balls, are sweet scented and attractive to insects. The curved pods are 2–3 inches long and ¼ inch wide, and commonly eaten by goats in Tanganyika.

It is not known to what extent the gum of *Acacia senegal*, the well-known "hashab" of the Sudan, enters into the export gum trade of Tanganyika. However, it is believed that in the low rainfall areas of central Tanganyika considerable quantities of *Acacia senegal* are present, and that a large pure stand exists at Kikhunkumo (MALCOLM). The tree also occurs in Uganda and Kenya. It is also not known with any certainty how the gum obtained from the tree in Tanganyika compares with that obtained from the tree in the Sudan, and whether it is of the same high quality. One sample examined at the Imperial Institute was found to be similar in all respects except viscosity. This was low, 5.21 as against 13.50 for the Kordofan product (viscosity at 20°C: 10% solution). It is thought the difference in season may have been responsible (MALCOLM), but obviously further comparisons are desirable.

The other species of *Acacia* from which it is thought gum may be collected for the export market in Tanganyika include—*A. fischeri, A. stenocarpa, A. spirocarpa, A. stuhlmannii, A. kirkii, A. seyal* and *A. malacocephala.* One observer (D. B. BURTT, specimen 5530, 1936) has reported the last mentioned species to be one of the principle sources of gum in the Shinyanga district (Wembare region). Analyses of the gum of most of these are referred to by MALCOLM. Additional species in Tanganyika known to exude gum are *A. sieberiana, A. benthami, A. orfota, A. usambarensis, A. mellifera, A. arabica, A. albida* and *A. xanthophloea* (P. J. GREENWAY 1941).

Collection and Marketing:—In Tanganyika the gum collecting season commences soon after the termination of the rains in May or June and ceases when the "short" rains arrive in November. The season is therefore the reverse of that in the Sudan which is from November to June. Gum collectors in Tanganyika usually carry a long, forked stick and some form of container, either of cloth or basket-work. The long stick which is used for removing tears of gum from the higher branches, is not, however, universal, and some collectors use spears instead. Occasionally trees have been felled for the sake of gum which was out of reach.

Regarding the collection of gum in Tanganyika MALCOLM states:—

"Gum pickers can be divided into two distinct classes—(a) those who habitually collect gum every year. (b) casual gum collectors.

(*a*) Habitual Gum Collectors.—This class of collector is composed largely of men who leave their homes and travel, sometimes considerable distances, to the areas which have a reputation for gum production. This pilgrimage is a perennial fixture and is often begun during or even before the harvest and extended to a sojourn of several months in the "Ilula" bush. These collectors live in the villages near the Acacia scrub or in camps scattered throughout the seasonal swamps which are dry and cracked at that time of year. Food is brought to them from time to time by their families, who sometimes assist them to carry the fruits of their labours to market. Water is usually available near villages, and digging in the river bed is often successful.

(*b*) Casual Gum Collectors.—This class of gum collector, which probably accounts for more than half the annual production, consists of men, women and children who live close enough to the gum-producing areas to be able to spend a few days collecting without any elaborate previous arrangements such as are entailed by a prolonged journey. These people, finding the family stock of salt or cash is exhausted, or wishing to supplement the receipts obtained by the sale of their crops, go into the "Ilula" bush and collect gum to the value of about twenty cents a day each (September 1934 prices). Sometimes they only visit the outskirts of the gum area, where a smaller quantity is obtainable at the end of a shorter march.

Gum collecting entails an unaccustomed eye-strain, produced by gazing at the higher branches against a brilliant sky, and a complementary pain in the neck; consequently economic pressure must outweigh these hardships before a native will engage in this industry.

If each collector picks three pounds per day for a fortnight, then nearly forty thousand people are engaged in gathering the average annual export tonnage from Tanganyika, and it is probable that the actual number of collectors in the Territory is more than forty thousand picking less per day over a shorter period."

Tapping the trees by removing a strip of bark, as practised in the Sudan is not carried out at all by the natives in East Africa, nor is any other form of deliberate tapping practised for Acacia gum. All the gum collected is what exudes from the trees naturally. If the bark stripping method of tapping could be introduced with suitable species, *i.e.* those with a fibrous as distinct from a fleshy type of bark, it is probable much larger quantities of gum would be available. Unfortunately, the system of land tenure, tribal and social customs are likely to cause difficulties that are not easily overcome. It is natural that a native should be unwilling to go to the trouble of tapping the trees in an area when he knows someone else may take the gum.

Grass fires occur in the main gum yielding areas in Tanganyika and are believed on the whole, to stimulate rather than inhibit the production of Gum. This is because most of the important gum yielding species (including *Acacia drepanolobium, A. seyal* and *A. seyal* var. *fistula*) are fleshy barked, *i.e.* possess a thick fleshy bark rather than a relatively thin fibrous one. A grass fire has the effect of drying and cracking the damp fleshy bark and so encouraging the production of gum. Frequent fires may, of course, be harmful in the long run for they cause the destruction of so many young trees and seedlings. In the case of thin barked species, like *Acacia senegal,* fires may cause severe injury to older trees.

As gum picking takes place in the dry season the question of water supply is an important one for the collectors and is a factor in determining the extent of country that may be picked over for gum. The distances between permanent water supplies are not so great as they are in the Sudan where the same problem exists, but which is alleviated to some extent by animal transport (camels), whereas in Tanganyika, the gum is invariably carried by head load to the nearest centre. This lack of animal transport also has a bearing on the marketing of the gum and accounts for the large number of small markets that exist in contrast to the position in the Sudan where one central market serves a wide area and large loads may be transported long distances by camels. In the Sudan separate markets exist for gum whereas in Tanganyika gum is commonly sold on the general markets.

Much of the gum is purchased from the collectors by itinerant traders, many of them Arabs. Cloth or other goods may be given in exchange. The collectors often receive very low prices for gum sold in this way and the trade is a lucrative one for those engaged in it. It has been recommended that the itinerant trader should be abolished and the gum sold only in properly constituted markets where the activities of such buyers would be subject to Government supervision.

The sun bleaching of gum, as practised in the Sudan, which has the effect of imparting a uniform light colour to the product, is not done in Tanganyika.

There is also little or no grading carried out by exporters in East Africa, this being done by dealers in Bombay, the port to which most of the East African gum is shipped. After hand picking and grading there, and possibly being mixed with gum from India itself, North Africa ("Aden gum") or Arabia, it is exported to European, American or other markets as "East Indian gum arabic." The hand picking and sorting in Bombay is carried out by women who are skilled and experienced at the work.

The favoured position of East African gum on the Indian market as compared with Sudan gum is because it has free entry into India and does not carry heavy royalties. The Indian market is accustomed to mixed quality gum and undertakes grading, for which cheap but experienced labour is available, as a matter of course. On European and American markets, on the other hand, only the light coloured good quality gums of the Kordofan type, that do not require hand sorting, are favoured. Mixed quality gum that needs to be picked over is frowned upon owing to the cost that this involves.

Other Countries Producing Acacia Gums

North Africa—Excluding the Nile Region:—Gum yielding Acacia trees are widely distributed throughout the greater part of northern Africa and gums of the gum arabic class may be exported from various countries other than the Anglo-Egyptian Sudan.

Morocco is one of the countries in which an export gum trade has existed in the past, the gum being known in the trade as "Morocco," "Mogador", or "Brown Barbary" gum. The importation of gum from this source to the United Kingdom ceased or became negligible many years ago, but in the early years of the present century the quantity imported annually was in the neighbourhood of 50–100 tons, while the total export from Morocco from the ports of Mogodore and Saffi was some 400–500 tons. The gum was generally dark coloured and inferior to Kordofan gum with medium sized tears often vermiform in shape. The botanical sources of the gum were believed to be *Acacia gummifera* or *A. spirocarpa* and *A. arabica,* while it is considered probable that a certain amount of gum of *A. senegal* may have been brought overland and exported from Morocco as "Morocco gum."

Somaliland and Abyssinia, where the genus *Acacia* is well represented, are also gum producers. Gum has been produced by Somaliland for hundreds of years. The greater part of it is said to be shipped to Aden and is either exported to European countries (as "Aden gum") or to Bombay when it becomes "East Indian gum." At Aden it is often mixed with gums from elsewhere (Arabia) before export.

Apparently four main classes of gum are distinguished by native collectors in British Somaliland—"Adad," "Jalefan," "Hobloho" and "Nujal." "Adad" is the best quality gum and is believed, although with some uncertainty, to be derived from *Acacia senegal.* "Jalefan" is also from an *Acacia,* but the trees are not so plentiful as "Adad" and their botanical identity is doubtful. The two gums are frequently mixed by collectors. "Hobloho" and "Nujal" are inferior gums and are kept separate. The best gum-yielding *Acacia* ("Adad") occurs on both limestone and sedimentary slate soils, usually at altitudes of 2,000-3,500 feet. It is very prevalent in many parts and may be so thick as to make progress difficult. The Sudanese method of tapping by tearing off strips of bark is not practised, but in some parts of Somaliland the natives deliberately bruise a few square inches of bark to encourage the production of gum. However, this is not regarded as a very satisfactory method for the gum is not produced in tears so cleanly as from a wound (Bull. Imp. Inst. **26**: 378-382). It is believed that *Acacia abyssinica* and *A. glaucophylla* are among the other Acacias from which gum is collected in British Somaliland. According to J. B. GILLETT (Specimen no. 4742, 1932), *Acacia bussei* is a common Acacia in parts of British Somaliland and natives sometimes collect the gum to eat although not for sale. The ripe seeds ground up are also eaten. This species occurs in East Africa. The gum of *Acacia mellifica* is also sometimes collected (C. N. COLLENETTE: specimen no. 22, 1929).

In British Somaliland licenses are issued to natives for gum collecting and an export duty is charged on the gum.

Southern Africa:—Acacias are a characteristic feature of the vegetation of a large part of southern Africa and are the main constituents of the thorn veld. Some 38 species are known to occur in South Africa, several being very widespread and common. They are notably conspicuous in many parts of Transvaal, Natal, Bechuanaland and South West Africa. In some districts, as in the Ladysmith area of Natal, the indigenous Acacias have increased considerably on farms and severely encroached on the grass land used for grazing, much to its detriment.

Gum is produced sporadically on the trunks or branches of most of the thorn veld Acacias in southern Africa, but there has been little attempt to collect it systematically or on a large scale. Only in a few instances has the gum of individual species been investigated or submitted to trade buyers and users for report and commercial valuation. Where this has been done reports have generally been unfavourable, the gums being unable to compete in open competition with Sudan gum on account of inferior colour or inferior adhesive properties. However, it is interesting to recall that at one time, before the growth of the Sudan gum trade, there was a trade in "Cape gum," believed to be derived largely from *Acacia karroo* (syn. *A. horrida*). Quite considerable quantities were shipped to European markets last century. Gum from South West Africa, known in the trade as "Angra Pequena gum" (believed to be mainly *Acacia karroo*) also reached European markets, particularly Hamburg.

A sample of South African acacia gum, probably derived from *Acacia karroo*, examined at the Imperial Institute (Bull. Imp. Inst. **15**:111-112), was found to consist of small fragments of clear gum varying from almost colourless to reddish brown. It yielded a mucilage with good adhesive properties although the viscosity of a 10% solution at 22°C. was 8.0, against 12 for that of hard Kordofan gum. The acidity was higher than that of good Sudan gum. Attempts to market South African gum in the United Kingdom in the present century have been unsuccessful except when Sudan or Senegal gums have been scarce and dear. Uncertainty of supply has also been an adverse factor in procuring a regular overseas market. A certain amount of local acacia gum is consumed in South Africa in pharmacy and as an adhesive by stationers and printers. The gum was used medicinally by the early settlers and being often sweetish in taste is eaten by children.

Acacia karroo is one of the most common Acacias in South Africa and is known as "witdoring," "white thorn," or "karroo thorn." It occurs abundantly in the Cape Province, Natal, Orange Free State and Transvaal and is probably the most abundant tree in the savannah areas known as the bushveld. As the tree occurs scattered over wide areas and is not as a rule found in abundance near the larger centres of population, but in remote parts where even the native population is sparse, it is thought large scale collection would involve many difficulties. However, if prices were sufficiently high to induce natives to collect, doubtless considerable quantities of gum would be forthcoming (S. Afr. Journ. Industries **1**:761). As far as is known no attempts have been made in South Africa to ascertain whether the tree would respond to tapping as carried out in the Sudan.

A specimen of the gum of *Acacia karroo* from Northern Rhodesia in the Kew Museum (collected by Mr. C. G. Trapnell in 1935), consists of light, medium and dark coloured tears which indicates that the colour and therefore the quality of this gum is variable—probably with age.

The "kameeldoring" or "giraffe thorn" of southern Africa, well known for its large sweetish, though astringent pods, which are eaten by livestock, may also yield gum which is said to be similar to that of *Acacia karroo.*

India:—Some two dozen species of *Acacia* are indigenous in India and of these a number are important sources of gum for the local inhabitants. Most of this is consumed locally for edible purposes but a good deal finds its way to gum markets in Bombay and other centres. As collected by the natives these Acacia gums are usually mixed with any other non-Acacia gum that may be in the neighbourhood. Throughout India there are a large number of gum-yielding species and in the wild state they generally occur intermixed. Native Indian gums are therefore notorious for their mixed character and pure Acacia gums are seldom to be seen in the markets and bazaars.

Bombay has long been an important centre and port of export for gum. Both Indian gums and those imported from elsewhere, notably Aden, the Red Sea ports and East Africa, are cleaned, hand picked and graded in Bombay before being exported. It is believed that very little of the actual Indian produced gum enters into the large export gum trade of Bombay, and that this is largely a re-export trade of African and other gums, usually referred to as "East Indian gum arabic" (J. F. CAIUS and K. S. RADHA 1939).

Indian gum arabic is the term used for gum produced in India to distinguish it from the "East Indian" already referred to and the true gum arabic of European commerce which is of course of Sudan or Senegal origin and the product of *Acacia senegal.* Some of this refined gum is imported to India for pharmaceutical purposes.

Acacia senegal does occur in India but only in the north eastern area, being found chiefly in Sind, Rajputana and the Punjab. It is common on dry rocky hills. In Sind it is known as "khor" and in Rajputana as "kumta". As in Africa it produces a good quality gum and the best classes of Indian gum are often composed largely of it. Unfortunately its restricted distribution in India severely limits the quantity of gum available.

In contrast to the above *Acacia arabica* has a very wide distribution in India and is the source of much of the gum reaching the bazaars and markets. Commonly known as "babul" or "babool" it is one of the commonest trees in the drier parts and occurs not only wild but cultivated also, for its wood, bark and pods, the latter being used in tanning. It also occurs in Assam, Burma, Ceylon and westwards to southern Africa. Many varieties of the tree exists which differ from one another mainly in pod characters. *Acacia arabica* varies in size from a small erect tree to a large heavy stemmed one with a girth as much as 8-10 feet and up to 100 feet in height. The bark is usually dark brown or blackish in colour and much furrowed. The gum exudes chiefly in March and April and a tree may yield as much as 2 lbs. Old trees yield the most gum but unfortunately the older the tree the darker the gum. Normally trees are not tapped in India and the gum exudes naturally. In this connection it is interesting to observe that in Africa a form of tapping is sometimes practised in that a section of bark 2–3 inches in diameter is cut out and the bark round the incision bruised with a hammer (J. M. Dalziel 1937). In the bazaars in India the gum is to be seen as irregular and broken tears agglutinated in masses. Half an inch is the average diameter of the tears and the colour generally reddish brown or straw coloured. The gum is not only markedly inferior to Sudan or Kordofan gum in colour but also in adhesive properties. According to Caius and Radha it forms the bulk of the "amrad" or "amrawatti" gum of the Bombay gum merchants.

Another widespread Acacia in India is "khair" *Acacia catechu,* the source of cutch, an important tanning extract. It is common in most parts of India and also occurs in Burma and Ceylon. Gum is often collected from the tree, especially in Gujarat, and appears on the bazaars or is eaten. The tears may be up to an inch in diameter and pale yellow to dark amber in colour. It is said to be sweet to the taste, soluble, and a better substitute for true gum arabic than "babul" gum (*A. arabica*) with which it is often mixed.

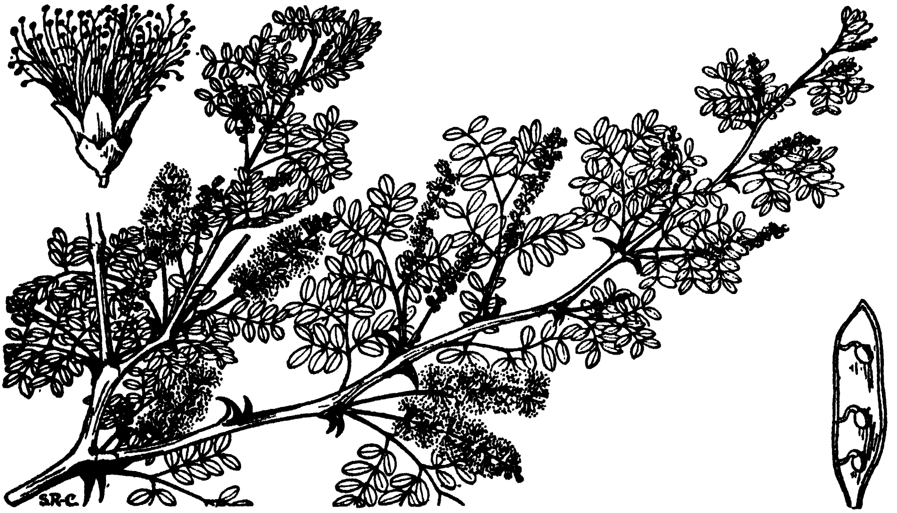


Figure 5.—**Acacia modesta** Wall. A source of "Amritsar" gum of the Bombay gum markets.

Acacia modesta, one of the characteristic trees of the Punjab, is another common source of gum. This Acacia reaches a large size with boles sometimes 10–12 feet in girth in the case of old trees. It occurs in the sub-Himalayan tract and outer Himalayas from the Jumna westwards and also to the Salt Range. It is much used for firewood, some areas having been cut over to such an extent that only coppice wood remains. The wood is durable, hard and heavy and turns dark brown with age. It is not ornamental or easy to work, but is used for cane crushers, Persian wheels and in well construction (R. S. Pearson and H. P. Brown 1932). The gum occurs mostly as small tears or angular fragments sometimes vermiform. It is translucent, yellowish in colour and forms a good pale coloured mucilage. The gum reaches Bombay markets under the name of

"Amritsar gum". Mixed with that of *Acacia arabica* it may also be termed "gum mamrah" on the Bombay markets (CAIUS and RADHA). A sample of the gum of this species in the Kew Museum from Jhelum in the Punjab is an exceptionally good, light colour and consists of small fragments.

Other Acacias in India from which gum is known to be commonly collected and which may be of fair quality are *Acacia farnesiana, A. jacquemontii, A. leucophloea,* and *A. ferruginea.*

According to CAIUS and RADHA:—"The Indian gum sold in the bazaars of Bombay may be roughly distributed into two groups according to the vernacular names under which they are sold: (a) *bavul, gundar, dink, kher;* (b) *maklai, ghati, katira, deshi, bavul,* etc. The 'bavul' or gum arabic group consists of 95 per cent of *Acacia* gums—*A. arabica, A. catechu, A. modesta,* and several other species. The other gums present in the group are those of *Anogeissus latifolia, Azadirachta indica, Feronia elephantum,* which have properties similar to those of *Acacia* gums, and are acknowledged as good substitutes for gum arabic. The rest are a negligible quantity. In the 'makli' or 'ghati' group Acacia gums are found to the extent of 40 per cent, mixed with other gums very different in their properties from gum arabic." This illustrates the importance of the Acacias in the Indian gum trade.

Australia:—The genus *Acacia* is very well represented throughout Australia where over 300 species are indigenous and are known locally as "wattles". Gum has been recorded and described from a number of these species especially during the latter part of the last century, a time when there was an export of gum from Australia to the United Kingdom and other countries. This export trade ceased early in the present century when Australian gum, on account of its natural inferiority, failed to compete with the increasing supplies of high quality Sudan gum that were then reaching world markets. In 1898 some 168 tons were imported into Britain, but by 1907 this had fallen to 26 tons. These imports were mainly from New South Wales and South Australia.

Wattle gum has been collected and put to minor local uses since the days of the early settlers in Australia and before that it was a common article of food with the aboriginals as the writings of the early travellers and explorers indicate (*see* Chapter I).

Australian Acacia gums vary a great deal in their quality as has been clearly pointed out by MAIDEN (1890), and even the gum of the same species from different areas may show marked differences in solubility and colour. It is poor solubility and dark colour that accounts for the low grade or low commercial value of the average sample of Australian Acacia gum. A few species would appear to generally yield pale coloured gums of good solubility that compare well with Sudan gum arabic, but this is exceptional, most gums being reddish brown with a marked taste and a strong tendency to form jelly rather than a mucilage with water. MAIDEN expressed the view that gum from the interior of Australia, an area that compares in climate and aridity with the Sudan and other notable gum producing countries, is on the whole far superior to that obtained east of the Dividing Range and in the coastal districts where rainfall and humidity are higher. The amount of gum obtainable from the interior districts, however, was small compared with that from the more populated coastal districts.

According to Maiden the best quality Acacia gums in Australia are yielded by *Acacia homalophylla, A. pendula,* and *A. sentis,* all being entirely and readily soluble in cold water. The first mentioned is a common tree ("gidgee") in South Australia, Victoria and New South Wales and may produce gum abundantly in the summer season. With *A. pendula* var. *glabrata* there may be a marked difference between new and old gum, the latter becoming much fissured. *Acacia sentis* yields gum that may be amber, sulphur yellow, or "nearly as pale as selected Turkey gum arabic" and considered by Maiden to be "a very acceptable article of commerce could it be obtained in quantity". Lower grade gums are yielded by *Acacia binervata, A. dealbata, A. elata, A. glaucescens* and *A. penninervis* and still poorer quality gum by *A. decurrens* and its varieties. Gum may also be yielded by *Acacia bakeri, A. cunninghamii, A. harpophylla, A. leiophylla, A. maideni, A. oswoldi, A. pycnantha, A. retinoides, A. salicina and A. verniciflua.* Analyses of most of these gums have been recorded (J. H. Maiden 1901).

Some of the Australian Acacias are now freely cultivated in other countries, especially for the bark which constitutes a valuable source of tannin, *e.g.* the "black wattle" *A. decurrens* var. *mollis* (syn. *A. mollissima*). They are also grown for firewood, as shade trees, shelter for live stock, for ornament or for colonizing and binding sand dunes. The "black wattle" has been freely cultivated in South Africa, especially Natal and in East Africa as a source of tanning material. It is also commonly cultivated in Java and India. Gum is often produced very freely by this species and in view of the quantity that would be available from wattle plantations, etc. if needed, the possibility of the gum having commercial value has been investigated on various occasions in the past. A good account of the gum and of the examination of material from Java has been given by M. J. van Royen (1929). The gum is often in very large tears, is generally a dark reddish brown in colour and may have a slightly fermented smell. The water soluble portion of the gum (about 25%) resembles gum arabic in adhesive properties but is inferior in that it is not colourless and tasteless. The insoluble portion of the gum (about 70%) becomes soluble in a weak soda solution (5%) but is of no value as an adhesive.

Certain other Australian gums, not derived from species of Acacia are dealt with in Chapter VI.

Chapter III

GUM TRAGACANTH AND SIMILAR GUMS

Gum Tragacanth

Botanical and geographical sources.—Gum tragacanth is obtained from several species of *Astragalus* that occur in the mountainous regions of Asia Minor through Syria and Kurdistan to Iraq and Iran. These plants are low, spiny shrubs somewhat resembling gorse (*Ulex*) and often inhabit dry exposed situations. Gum may be obtained from natural exudation or a form of tapping. The genus *Astragalus* is a large one with upwards of 1,600 species, and is more or less cosmopolitan in distribution but is not represented in Australia. Only certain, and by no means all species of *Astragalus* are known to yield gum when tapped or wounded.

Among the species that have been recorded as yielding gum are:—*Astragalus adscendens, A. brachycalyx, A. creticus, A. cylleneus, A. eriostylus, A. gummifer, A. heratensis, A. kurdicus, A. leiocladus, A. microcephalus, A. pycnocladus, A. strobiliferus* and *A. stromatodes.* The relative commercial importance of these different species is not known with much certainty, but a useful contribution to the subject has been made by G. E. TREASE (1936). This writer points out that *Astragalus gummifer* is an important source of the gum tragacanth exported from Asia Minor, known as "Smyrna" or "Anatolian" tragacanth and much used on the Continent of Europe, but less so in the United Kingdom. In the latter country the bulk of the tragacanth used is that termed in the trade "Persian tragacanth" and is derived from Persia (Iran), Turkish Kurdistan and Iraq. The following list, given by TREASE, shows the approximate distribution of the gum yielding species in the areas where Persian tragacanth is collected.

SPECIES	GEOGRAPHICAL DISTRIBUTION
A. gummifer	Northern Kurdistan, Armenia, Asia Minor and Syria.
A. kurdicus	Southern Kurdistan to Asia Minor and Syria.
A. brachycalyx	Iranian Kurdistan and Luristan.
A. eriostylus	Luristan.
A. pycnocladus	Kermanshab (Shahu and Avroman Mts.).
A. verus	Western Iran.
A. leiocladus	Western and Central Iran
A. adscendens	South Western and Southern Iran.
A. strobiliferus	Eastern Iran.
A. heratensis	Khorasan to Afghanistan.

The Kurdistan gum is exported largely via Baghdad and Basra, while that from Luristan may go to Mohammerah. Bushire and Bundar Abbas, on the north shores of the Persian Gulf, are the export centres for the Fars and Kerman districts. A certain amount of gum that is imported by the U.S.S.R. may be exported by the Caspian Sea and small quantities may go overland to India. A good account of the production and trade of gum tragacanth, as it existed last century, has been given by Tschirch (1908-25) and by Flückiger and Hanbury (1879).

Collection.—The gum is usually collected from plants growing at altitudes of from 4,000 to 10,000 feet. The plants are usually small and bushy, seldom exceeding a metre in height. Gum may be exuded naturally to some extent or be due to the wounds of grazing animals, but the better quality gum is always obtained by tapping or incising the roots. To do this the collector usually scrapes away soil from the base of the stem to a depth of about two inches and makes a vertical incision with a sharp thin-bladed knife. A wedge-shaped piece of wood may then be inserted in the wound to keep it open and left there from 12-24 hours.

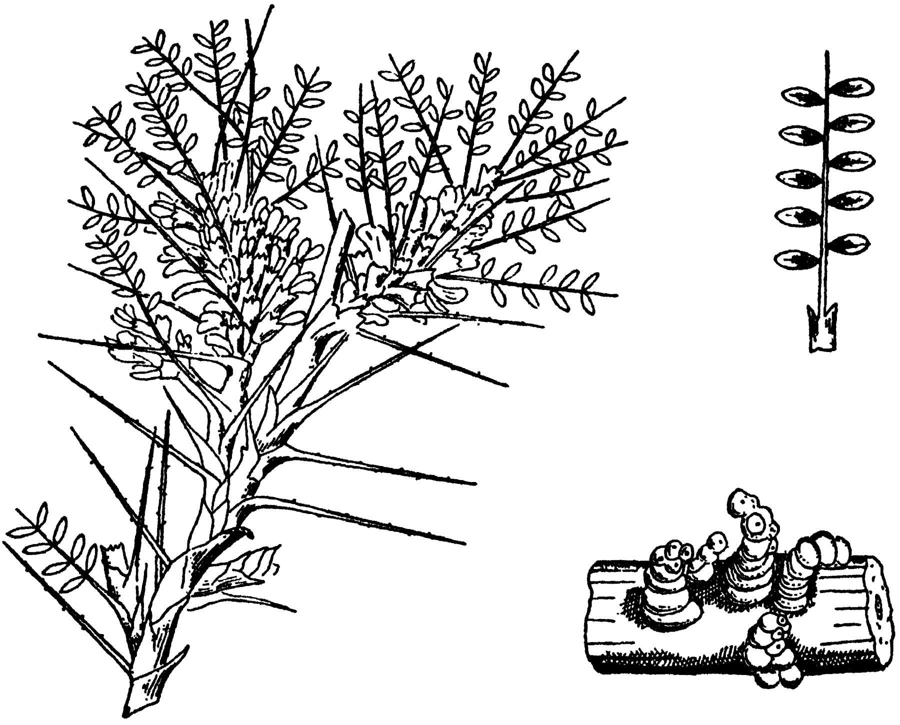


Figure 6.—**Astragalus gummifer** Lab. One of the sources of gum tragacanth.

Gum exudes from such wounds as thin ribbon-shaped flakes. These are collected as soon as they have hardened sufficiently, which may be only two days after making the incision. The rapidity with which the gum exudes largely determines the shape of the flake or ribbon and also the colour. Rapid drying is conducive to a good white colour, whereas, with slow drying the gum may be yellow, particularly if rain falls or wind rises carrying particles of dust on to the gum. The shape and form of the incision has a direct bearing on the nature or form of the ribbon that exudes.

In some districts the practice is to burn the tops of the bushes after making the incision in order to induce greater gum production, but this results in yellow or discoloured gum and is a bad practice liable to kill the bushes. If the stems of the bushes are punctured instead of being incised, the resulting gum is vermiform and not ribbon-like. Such gum has been termed "vermicelli" in the trade. Gum that exudes naturally may be in globular or conical shaped pieces. Another form, known as "arrehbor" in Persia, exudes from branches that have been cut with a saw.

In the Fars district, according to TREASE, collection starts in May in the warmer districts, and later in the colder areas, which supply the better gum. Plants are ready for tapping after their second year. They may be tapped when a year old but this gives a poor quality gum, unfit for commercial use. The profitable life of the bushes has been estimated to be about seven years.

Grading and marketing.—After the gum has been collected by villagers and sold and is in the hands of the middleman or exporter, it is graded according to size, shape and colour. The best grades ("druggist's ribbons") consist of thin translucent flakes, pure white in colour, while the poorest grades are in the form of dark coloured irregular lumps ("hoggy pickings"). The leaf grades are intermediate in quality and price. A wide difference in market value exists between the different grades as the following extract from a London market report (1945) indicates—"Pharmaceutical and fine grades, 1st quality £133 per cwt.; 2nd quality £120; 3rd quality £100-105; pale leaf £75-83; amber to yellow £48; yellow leaf £43; "hoggy" £17-10-0. On the London market gum tragacanth, other than that from Asia Minor, is distinguished as "Baghdad" or "Syrian" when it comes from Baghdad or is shipped from Basra, and "Bushire" or "Persian" when it is from the Fars district or is shipped from Bushire. The greater quantity is shipped from the Persian Gulf ports.

It is difficult to estimate the quantity of gum tragacanth exported from Persia or neighbouring countries in the course of a year. However, from figures quoted by TREASE over a nine year period (1925-36) the gum tragacanth export from Persia represented from 1-2% of the country's total annual exports and varied in value from 9-22 millions of krans or rials (the rial having varied in value from 50-100 per £1). The trade is thus of some importance to the countries concerned. During the five year period 1940-44 the quantity of tragacanth imported into the United Kingdom varied from 364 tons to 1070 tons with an average annual import of 651 tons, in spite of war conditions (Board of Trade 1945).

The properties and uses of gum tragacanth are dealt with in Chapter I.

Karaya Gum:—Karaya gum or Indian tragacanth as it is also called, is obtained from *Sterculia urens*, a widespread tree in India. The gum has long been used in India but it is only in comparatively recent years that it has appeared in any quantity on the markets of Europe and America as a substitute for gum tragacanth. It is collected for sale in many parts of India and is largely used for making native sweetmeats. The gum has also been used in Indian hospitals for many years in the place of tragacanth. In the natural state it is in irregularly shaped pieces, sometimes of worm-like appearance. They are white or pinkish-brown in colour and generally striated. Often fragments of bark are attached. The gum, especially when fresh, may have an acetous odour.

Sterculia urens is a large deciduous tree with a characteristically smooth, white or green-grey bark which peels off in large, thin, papery flakes. The inner bark is fibrous. This light coloured smooth bark, which is about half an inch thick, makes the tree conspicuous in the forest, especially in the dry season. The tree is characteristic of dry rocky hills and plateaux and is common in the dry deciduous forests of northern and central India. In parts of the Deccan and Chota Nagpur it is very prevalent (R. S. PEARSON and H. P. BROWN 1932). It occurs also on the west coast, in the Konkan and Kanara, and in the dry forests of Burma and Ceylon, but is generally rare in Ceylon, being probably introduced. The leaves occur at the ends of the branches, are 5 lobed and 9-12 inches in diameter. They have long petioles, 6-9 inches long and the undersurface is velvety. The flowers are small, unisexual and inconspicuous. Local names for the tree throughout India are numerous and the following are some of the better known:—"gular," Hind: "Kulu," "Karhar," C. P.: "Tele" Kol.: "Karai," "Kandol," Mar.: "Katira," Garhwal: "Vellay-putani," Tam. The wood is soft and reddish brown in colour with an unpleasant smell and is sometimes used in making native guitars and toys, while the seeds of the tree are roasted and eaten by some tribes.

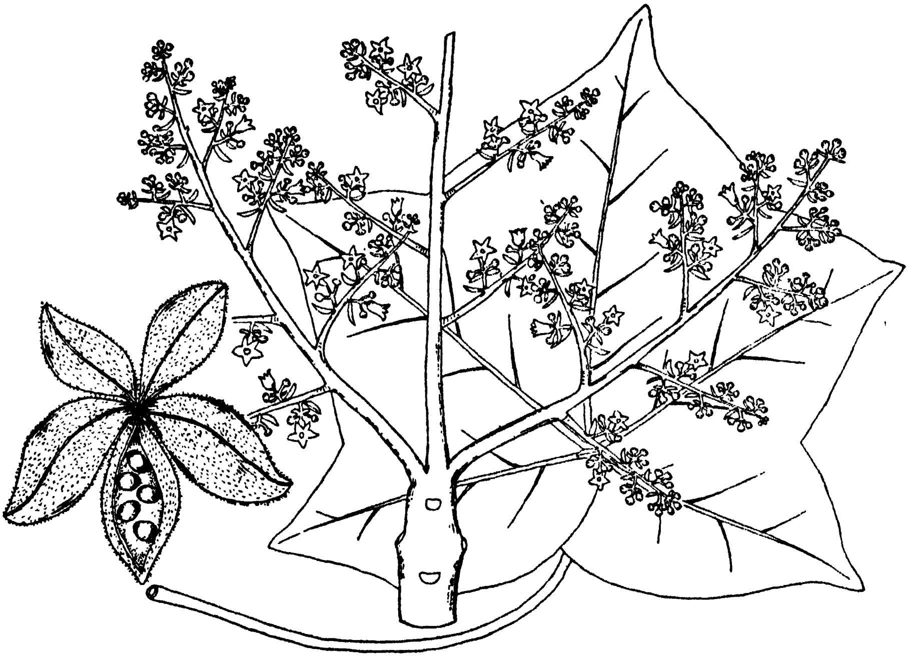


FIGURE 7.—**Sterculia urens** Roxb. The source of karaya gum or Indian tragacanth.

Gum is produced freely by the tree and even by cutting off a young branch the gum is seen exuding as a soft solid mass from large canals in the pith and bark. Even young tissue seems to have the gum present, such as branches of the inflorescence and the petioles of the leaves. In the branches it seems to be retained with some tension, for in a short time it may be exuded to the extent of about half an inch.

Two forms of the tree are said to exist in some parts of India, the red and the white barked. The former is reputed to yield more gum and it is also considered that trees on hill slopes supply more gum than others (KESAR SINGH 1935).

When the demand for Karaya gum on world markets suddenly developed some 15 years ago and increased prices were paid for it in India, trees were rather ruthlessly tapped and exploited in some areas, which resulted in severe damage and death of trees. Legislation had to be introduced to control this in some instances. In tapping, portions of the trunk are blazed or the bark cut away. Gum exudes straight away and continues to form for a few days, but is greatest during the first 24 hours after blazing. It forms as strips, tears or vermiform pieces and is stripped off by the collectors who visit the trees every few days in the season. In the United Provinces, the tapping or collecting season is roughly from October to January, and April to June, the latter period affording the better gum.

The gum is usually classified and sold in three different grades, 1st quality—white, 2nd quality—pinkish, and 3rd quality—blackish. When the 1st quality gum has sold at Rs. 40 per maund the second quality has stood at Rs. 25 and the third at Rs. 15. Gum may exude naturally from the trees throughout the year but during the rains is prone to become dark or blackish in colour.

The method of tapping or blazing the trees has an important bearing on their health and their life, and it would seem that the tree is easily injured and its vitality impaired. It is recommended that 'kulu" trees under three feet in girth at breast height should not be blazed (KESAR SINGH), and that the blaze should be cut so that the edges slant to allow water (from rain) to run off, for water retaining pockets are liable to cause rot. The size of the blaze is also important. It is considered this should not be greater than about a square foot and not more than two blazes, inflicted on opposite sides of the trunk, should be made at any one time. A blaze 18 ins. x 16 ins. is said to heal in 12 months. Old blazes should not be reopened and new ones not made immediately next to old ones. The quality of the gum deteriorates with excessive tapping of the trees. Blazing too deeply and exposing the wood commonly leads to borer attack which may result in the death of the tree. After the first collection of gum has been made the edges of the blaze are scraped to encourage the further production of gum. An 1/8 inch scrape is regarded as quite sufficient. It is considered that trees should not be tapped continuously but be given long rest periods. Heavy tapping is believed to impair the fertility of the seeds and so affect regeneration.

The yield of gum of mature trees in the United Provinces has been given at from 1-5 seers of gum in a season. As a tree may safely be tapped 5 times in its lifetime its total yield might be 5 times this amount. The value or potential value of a tree for its gum therefore, compares well with the value of the other forest trees that occur with it.

In the Damoh division of the United Provinces the gum collected by the Forest Department in the Government forests in the 1935-6 season amounted to 1,604 maunds, valued at Rs. 11,868 with collection costs at Rs. 5,113. The actual cost of collection was given at Rs. 5-6.4 per maund for white gum, Rs. 3-12 for red and Rs. 2-8 for black. The only grading necessary was the separation of the black gum from the red and the white.

According to MANTELL (1947) Karaya gum has been known in the United States since the end of the 19th century but it was not until the first World War, when gum tragacanth was scarce and the price high, that it was extensively used. Some of the gum sold as tragacanth in the United States in the past has been Karaya. Latterly Karaya imports into the United States were far in excess of those of tragacanth, often more than double. In 1939 imports to the United States were in excess of 7,600,000 lbs., valued at $575,000. Karaya gum is now used in many industries as a substitute for tragacanth. For some purposes it is regarded as superior and has the advantage of being less expensive (*see* page 15).

Carob Seed Gum:—The carob tree (*Ceratonia siliqua*), like the olive (*Olea europaea*), has been a useful tree to mankind in the Mediterranean region since time immemorial, its sugary pods having provided a wholesome food for man and beast for countless generations. The pods are still much used for feeding domestic animals, although they may be used less now than formerly as human food owing to the use of other foods and a general higher standard of living. There are many references to the use of the carob or locust in classical and biblical literature. The "husks" spoken of in the New Testament as eaten by the prodigal son and the "locusts" that ST. JOHN lived upon in the wilderness are considered to have been the carob, hence the name "St. John's Bread Tree." In more recent times the pods were almost the only available food for the cavalry horses in WELLINGTON's Peninsular Campaign, and, in the present century, for ALLENBY's Campaign in Palestine in the first world war.

The tree is indigenous in the countries bordering on the Mediterranean and extends into Asia Minor, but has now been introduced and cultivated in many other countries where the climate is suitable, often as a shade or ornamental tree or as a shelter belt. These countries include California and parts of Australia and southern and eastern Africa. The carob tree is evergreen and requires a warm climate, being unable to withstand frost or snow. For this reason it grows best at the lower elevations and near the sea. Like the olive, the tree is extremely drought resistant and is often cultivated in ground that is unsuited or too stony for other crops. It will often thrive under arid conditions where few other trees will grow and owes its drought resistance largely to its deep penetrating tap root. The tree is exceedingly productive under conditions well suited to it, and yields upwards of 1,000 lbs. of pods have been obtained from mature trees. A good account of the cultivation of the carob in various Mediterranean countries and elsewhere has been given by J. RUSSEL SMITH (1935). The wild carob has a light coloured, thin, papery pod containing little sugary matter. The cultivated trees on the other hand, which are propagated vegetatively, have larger pods which are dark brown in colour and which resemble in size and shape those of the common broad bean (*Vicia faba*). They are rich in the sugary, brown powdery matter that surrounds the seeds.

In Mediterranean countries the pods have long been used as a foodstuff for live stock, especially horses and pigs, being fed either whole or coarsely ground (kibbled). They contain roughly 50% sugar and the food value is about similar to that of cereals. They have long been exported to other countries for use as stock feed. In the years preceding the second world war the quantities imported to the United Kingdom alone were in the neighbourhood of 50,000-60,000 tons annually. The greater part of this was obtained from Cyprus, with smaller quantities from Portugal, Algeria, Italy and Crete. The pods are largely used in the manufacture of feeding cake for cattle, but may also be fed whole or coarsely ground. The small, extremely hard seeds are an objectionable feature when fed in this form, particularly for sheep, as they sometimes cause trouble with these animals. The pods have also been used in the manufacture of dog biscuits and at one time were sold in sweet shops in Britain as sweets or candy for children. In Germany the pods have been sold in grocer's shops to be roasted as a coffee substitute, and in Spain they are sometimes blended, like chicory, with coffee. In Egypt and other parts of the Levant, sherbets or drinks are made from them. Alcoholic drinks are also prepared from infusions of the pods. When distilled, the pods may yield 18% good spirit. Mixed with chocolate in moderate proportions it is palatable and an extract has been used to flavour certain brands of French chocolate. In Cyprus brittle candy, called "pasteli" is made from it and used as a laxative sweetmeat.

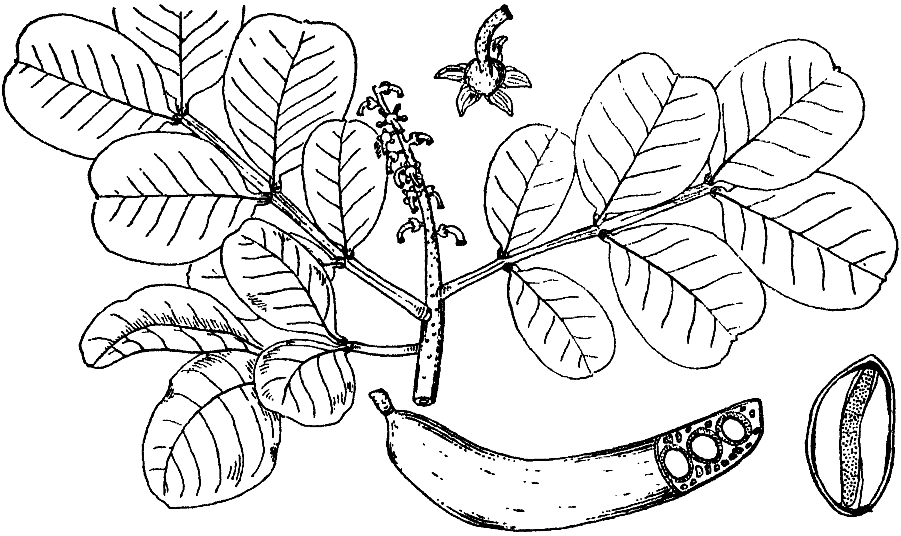


FIGURE 8.—**Ceratonia siliqua L.** (the carob). The source of carob seed gum.

The hard seeds have long been regarded as an objectionable feature of the pods when used as a stock food, being removed in the manufacture of feeding cake and looked upon as a useless or waste product. In recent years, however, important uses have been found for them, *viz.* as a source of high protein flour free from sugar and starch and now employed as a diabetic food. This flour ("profarin" or "trefarin") is pale yellow in colour and contains the high proportion of 60% of protein. It is well suited for baking and cooking purposes.

The seeds of the carob when dry are somewhat flattened, roughly oval in shape, and 8-9 mm. long. Their uniformity was responsible in earlier days for their being used as a standard goldsmith's weight of four grains—the carat; the word being derived from an Arabic name for the tree "gîrît." In cutting a seed across, which is difficult owing to its ivory-like hardness, it will be seen to consist of two distinct tissues. There is a central yellow band consisting of the two cotyledons which together with the embryo or "germ" are the source of the high protein flour referred to above. On either side of this central band are two segments of hard, white, horny tissue (endosperm). It is this tissue that contains the gum. If these two segments are removed and placed in water for a time, they will swell considerably and exhibit their gummy nature.

The presence of a large amount of gum in the seed has long been known, but the difficulty hitherto has always been to separate the gum from the other constituents of the seed. However, the development of ingenious mechanical processes for separating the gum containing endosperm from the rest of the seed has brought into being "carob gum" or more correctly carob seed gum, now an established commercial product with many uses. The gum is sold under various proprietory names (*e.g.* "tragasol," "luctin") and is in effect a cheap substitute for gum tragacanth and may be used for many of the purposes for which true gum tragacanth is used. Thus the carob seed, so long regarded as useless and a troublesome adjunct of the sugary seed pod, has become the source of a useful gum and invalid food.

The analysis of carob seed gum has been given by Knight and Dowsett (1936) as follows:—

Galactan	29.18
Mannan	58.42
Pentosans	2.75
Proteins	5.29
Nitrogen	0.83
Cellular tissue	3.64
Mineral matter	0.82

An enzyme, ceratoniase, is also present.

Carob gum has largely replaced gum tragacanth in many important industries as well as for certain pharmaceutical purposes. It has been used "in the rubber industry to facilitate creaming of the latex, in paper-making as a size and in tanning. The use of colloids to facilitate penetration of the tanning solution has reduced the time required from months to a few days, with increased weight of leather produced and greater water resisting properties. The purified powder now commercially available forms a solution at least equal in viscosity to that of tragacanth, and is being used for thickening sauces and pickles in place of starches and tragacanth, for "smoothing" ice cream in place of gelatin and starches, and also in salad creams as an assistant emulsifier and for the partial replacement of eggs" (Knight and Dowsett). For certain pharmaceutical preparations (toilet creams, catheter lubricants, Kesbar cream for radiographic work, etc.) the gum has been found to be quite satisfactory (Knight and Dowsett), and the price is considerably lower than that of gum tragacanth.

Carob or Locust bean gum is extensively used in the United States, particularly in the textile industry. According to MANTELL (1947) the supplies of gum (not the seeds) are imported mainly from manufacturers in Great Britain, France and other Mediterranean countries. During the 10 year period 1929-1939 the average annual consumption of the gum in the United States was in excess of 2,000,000 lbs. with over 4,000,000 lbs. in 1939. American imports of Carob beans or pods from Mediterranean countries (1,500,000 lbs. in 1939) are utilized mainly in tobacco curing and not for the making of gum. The reason why the prepared gum rather than the seeds are imported is probably one of transportation costs for 1000 lbs. of beans are said to yield 100 lbs. of seed, and these only 35 lbs. of gum. The separation of the gum bearing part of the seed and the preparation of the gum has been the subject of various patents.

Kutira Gum:—This is another gum of Indian origin that has been exported and used as a substitute for the true tragacanth gums (*Astragalus* spp.) and has many points of similarity with "karaya gum" (*Sterculia urens*). The name "karaya" has also in fact, been used for it, which is confusing.

The tree yielding the gum (*Cochlospermum gossypium*) is common and widespread in the drier parts of India and the gum is consequently well known and often sold in the bazaars. It has long been used in India. The names "kutira," "katira" or "kathira" of Arabic and Persian writers on materia medica are used for the true tragacanth, the names having been transferred to the gum of this tree by early Mohammedan settlers in India. In Bombay the gum of *Sterculia urens,* called "karai gond" by the Guzeratti shopkeepers, may be sold by Mussalman druggists as "katira." Thus the names "kutira," and "karaya" or "kadaya" may be used somewhat indiscriminately for the gums of *Cochlospermum gossypium* or *Sterculia urens.* The two gums, although similar, are by no means identical.

Cochlospermum gossypium is generally a small tree or shrub with short, thick, spreading branches. The leaves are near the ends of the branches and are 4-9 inches in diameter, palmately lobed, and tomentose on the lower surface. They have long, slender petioles 4-6 inches long. The flowers are large and arranged in few flowered terminal panicles. They are 4-5 inches in diameter and golden yellow in colour with silky sepals. The pendulous fruits or capsules are 3-4 inches long and about the size of a goose egg. Owing to the brilliant yellow flowers, which often appear in the dry season when the tree is leafless making it very conspicuous, it is often planted near temples. The tree is in fact always conspicuous whether leafless or in full foliage with its glossy green palmately lobed leaves, or when the fruits are ripening and liberating their fibre covered seeds. The seed floss, analagous with kapok, has been used in India for stuffing pillows. This seed floss is very soft and elastic. It accounts for the specific name used for the plant. An oil may be obtained from the seeds, but this is little used. The bark of the tree is about an inch thick, fibrous and deeply furrowed, and has been used as a local cordage fibre. Little or no use can be made of the wood which is hardly more than a loose bundle of fibres when dry, and a soft spongy mass when green. Although of no value for its wood, the tree is regarded as useful sylviculturally as helping to reafforest bare, rocky, stony slopes and so preparing the way for more valuable species (J. S. GAMBLE 1922).

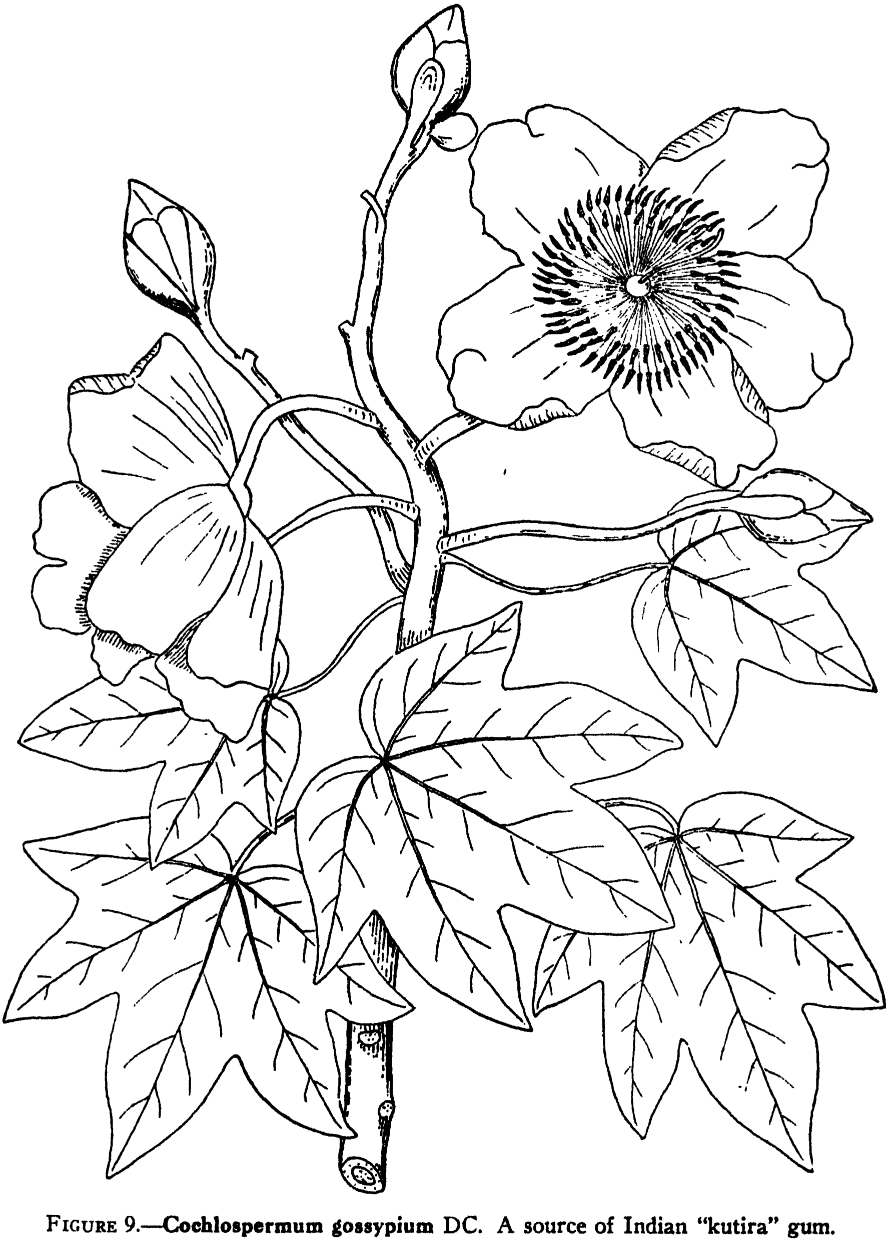


FIGURE 9.—**Cochlospermum gossypium** DC. A source of Indian "kutira" gum.

The tree is characteristic of hot, dry, stony slopes, and is widely distributed, especially in Northern India. It is common in forests at the base of the West Himalaya and extends from the Sutlej eastwards and in Guzerat, Central India and the Deccan. It also occurs in parts of Ceylon, Burma, Siam, Indo-China and the Malay Peninsula. In the last mentioned country, it has been recorded from Penang and Malacca but is regarded as having arrived at both places through cultivation. In the humid climate of Singapore it can be cultivated, but not with perfection (I. H. BURKILL 1935). The tree has been introduced into other countries *e.g.* East Africa (P. J. GREENWAY 1941). With its wide distribution in India the tree is known by numerous local names.

Kutira gum usually occurs in fairly large, clear, rounded lumps of irregular shape and often striated or twisted and semi-transparent. The colour may be white, pale buff, straw coloured or pinkish. The lumps show a tendency to split up into flat scales or large flat pieces. When moistened, the gum swells up like tragacanth into a bulky transparent jelly, but is only sparingly soluble in water. The gum has the remarkable property, also possessed by the gum of *Sterculia urens*, of giving off acetic acid when exposed to moist air. It is more readily pulverized than is gum tragacanth.

An account of the chemistry of this gum has been given by H. H. ROBINSON (1906). It was found to be free from starch and to yield a stable and probably dibasic acid ($C_{23}H_{26}O_{21}$), for which the name gondic acid was proposed. The yield of acetic acid was 14% of the gum, or 18% calculated on the dry and ash-free substance. By the action of sodium hydroxide solution in the cold, the acetyl group was removed and a gummy substance, which had acid properties, obtained. For this the name of α-cochlosperminic acid was suggested. As a result of his experiments, ROBINSON considered it possible that the gum itself was a tetra-acetyl derivative of cochlosperminic acid, which may be hexosan-xylosan-gondic acid. It was noticed that, like the arabinic acid prepared from gum arabic, gondic acid is rendered less easily soluble in water by prolonged drying at 100°. From the liquids from which the gum acids were precipitated by alcohol, two sugars were isolated with considerable difficulty. One was considered to be xylose, and the other possibly galactose or a new sugar.

This gum has been exported from India in increasing quantities in recent years (Quart. Jour. Pharmacy **10**:116), and the fact that the price has been low and stable, as compared with tragacanth, has led to new uses and applications for it in industry and pharmacy. It has been employed in the textile, cigar and ice cream industries. As a laxative it is considered to be superior to agar-agar, one teaspoonful being equivalent to two teaspoonsful of chopped agar. The gum has been used in place of psyllium seeds (*Plantago psyllium*). As an emulsifying agent it is a good substitute for tragacanth in some preparations, but its higher acidity is objectionable for certain purposes. For toilet preparations it has been widely used. In India it has been employed in the shoe making trade. It also appears to have been used in the marbling of paper and the edges of books.

Other Gums of the Tragacanth Type:—There are other species that are known to yield gums of similar appearance and a somewhat similar nature to gum tragacanth, *i.e.* gums that swell to a large jelly-like mass with water and are not soluble. For various reasons most of these gums have not been exploited to any extent in the past. In some cases the trees concerned are not particularly common or widespread. In other instances the gums may be rather dark coloured which naturally detracts considerably from their possible commercial value. In view of the increasing commercial uses that are being found for tragacanth and those gums that are well known as substitutes and readily available, it may not be out of place to refer briefly to some of these less known gums.

Many trees belonging to the genus *Sterculia* yield a tragacanth or karaya-like type of gum, but not always so freely as does karaya (*Sterculia urens*). The genus *Sterculia* contains over a hundred species widely spread over the warmer parts of the world. At least a dozen and a half are recorded as yielding gum. These include—*Sterculia campanulata, S. foetida, S. guttata, S. ornata* and *S. villosa* (from India): *Sterculia barteri, S. cinerea, S. setigera and S. tragacantha* (from Africa): *Sterculia acerifolia, S. diversifolia, S. platanifolia, S. quadrifica* and *S. rupestris* (from Australia): *Sterculia hypochroa* and *S. thorelii* from Indo China and *S. scaphigera* from China.

Sterculia cinerea is the source of a tragacanth-like gum from the Anglo-Egyptian Sudan known as "tartar gum." It is often pure white in colour and in large pieces. The tree occurs in other parts of Africa including Uganda, Kenya and Tanganyika. Were substantial and regular supplies of this gum available, and the gum carefully collected it would probably find uses similar to those of karaya gum for it has been favourably reported on.

Sterculia tragacantha and *S. setigera* (syn. *S. tomentosa*) are other species widespread in equatorial Africa that yield pale attractive looking gums resembling tragacanth. *Sterculia tragacantha* is a large tree reaching 80 feet, and is generally in the open parts or the edges of forests. It has a grey, corky bark through which the gum exudes, and conspicuous red purple flowers, followed by fruits which are red at first but later turn brown. The gum is often of a pinkish colour and resembles tragacanth. Besides exuding from the trunk, it is sometimes on the fruit follicles when these have been punctured by insects. Sometimes this gum is yielded in considerable quantity (DALZIEL).

Sterculia setigera is a common tree in many parts of West Africa, and has long been known as a source of tragacanth-like gum (DE CORDEMOY). In parts of Northern Nigeria in the savannah areas the tree is very prevalent (LELY) and usually grows much branched with a short bole. The tree is deciduous and its bark distinctive. "The bark yields a pale tragacanth-like gum and a watery sap which is refreshing to thirsty travellers. In the eastern Sudan this gum is called *da* or *kandi* gum, and is similar to that of *S. cinerea.* In the western Sudan tribes put it in food in place of baobab leaf where the latter is unobtainable. It is also used to prepare indigo-dyed cloth, and it is sometimes used in Europe for dressing fabrics, etc. In 2% solution it forms a colourless, slightly granular jelly" (Third Report, Well. Res. Lab., Khartoum, 1908: 438). The yield of gum in the dry zone is very small, but trees on river banks sometimes yield abundantly (DALZIEL).

Sterculia scaphigera is perhaps of special interest in that the gum is contained in the fruits and is not collected from the trunk of the tree as is usual. This tree occurs mainly in Indo-China and Siam and the fruits are an article of trade in the East. They are ¾-1½ inches long, ovoid, dark brown and deeply wrinkled externally. When macerated with water the pericarp or outer shell increases enormously in volume forming a gelatinous mass. The jelly is sweetened and eaten as a delicacy, especially by the Chinese who call it "ta-hai-tsze" and who regard it as a specific in diarrhoea and dysentery. The fruits are to be seen in Chinese pharmacies in Malaya (D. Hooper 1929) and are believed to be derived mainly from the Tatung mountains of Annam. They were imported to France at one time as a cure for dysentery but were found to act simply as a demulcent (Dymock, Warden and Hooper 1890-3).

Most Sterculias yield light coloured gums that show at least a superficial resemblance to tragacanth, but often they are lacking in adhesive properties. This applies also to many other genera in the family *Sterculiaceae*. It would appear, however, that some of the Australian species of *Sterculia* or *Brachychiton* as they are now called, sometimes yield dark coloured gums. Several well known Australian trees formerly included in the genus *Steculia* are now placed in the genus *Brachychiton*, the difference between the two genera being that the seeds in *Sterculia* are naked whereas in *Brachychiton* they are fibre covered. The gums of *Brachychiton diversifolius* (syn. *Sterculia diversifolia*) and *B. rupestris* (syn. *S. rupestris*) both of which are well known and distinctive trees in Australia, are said to be indistinguishable in physical properties from the well known Indian gums of *Sterculia urens* and *Cochlospermum gossypium*. In the Kew Museum some specimens of gum of *B. diversifolius* are pale yellow and not unlike tragacanth, whereas others are very dark in colour and in large lumps.

Brachychiton diversifolius ("kurrajong" or "black kurrajong") is a tree reaching from 20-60 feet in height and occurs in New South Wales, Queensland, West and North Australia. It bears yellowish white flowers mottled with purple, and has fruits 3 inches long. The leaves are variable in shape, entire or deeply lobed, and make good fodder for cattle and sheep. As much as a bucket of gum has been obtained from a single tree.

Brachychiton rupestris ("Queensland bottle tree") occurs in rocky places in the drier scrubs of Queensland where it is endemic. It is the best known of the "bottle trees" and is sometimes called "barrel tree" on account of the peculiar shape of the trunk. The pithy bottle shaped trunk may be 6 feet or more in diameter and is rich in a sweet mucilaginous or gummy juice (J. W. Audas 1935).

Quite a number of gums from trees in other families are described as "insoluble" and of the "bassora" or hog gum type. These include gums from *Moringa oleifera* (syn. *M. pterygosperma*), *Bombax malabaricum*, *Ailanthus excelsa*, *Stereospermum suaveolens*, *Terminalia catappa*, and some species of *Cycas*. The name "hog gum" has also been used for the exudation from *Symphonia globulifera*, a tropical American tree. This is in effect a resin which is yellow when fresh but blackens on exposure to the air. It is used by Indians for caulking boats and for torches.

Some of the so-called "Bassora gum" from Asia Minor that has appeared in European markets in the past is believed to be derived from one or more species of *Prunus*, but there is uncertainty in regard to this. The gum of *Opuntia ficus-indica* or "goma de tuna" is reputed (Tschirch) to resemble tragacanth.

Chapter IV

SOME WELL KNOWN OR MUCH USED ASIATIC GUMS

Gums from various trees are regularly collected for local use in India and other parts of Asia. Many of these gums are not normally exported and are articles of internal trade only, being used mainly for edible purposes but also industrially in some instances, *e.g.* calico printing or dyeing. The production and collection of gum is mainly associated with dry or relatively dry climates as has already been pointed out. Doubtless it is for this reason that India figures prominently among Asiatic countries as a gum producer. Over much of the country an arid climate prevails, in contrast to a good deal of the Asiatic tropics where high humidity and more or less continuous rainfall without a distinct dry season is the rule, *e.g.* Malaya and parts of the East Indies.

The following trees are sources of gum in various parts of the Asiatic tropics—*Aegle marmelos, Albizzia lebbek, A. odoratissima, A. procera, A. stipulata, Aleurites moluccana, Anogeissus latifolia, Bauhinia purpurea, B. retusa, B. variegata, Buchanania lanzan, Cedrela toona, Chloroxylon swietenia, Delonix regia, Elaeodendron roxburghii, Feronia acidissima, Lannea grandis, Mangifera indica, Melia indica, Prosopis spicigera, Sesbania grandiflora, Spondias* spp, *Terminalia* spp. As the gum yielding Acacias have already been dealt with in Chapter II they are not included. The extent to which the gum from the above mentioned trees is collected and utilized by the local inhabitants would appear to vary much from one country to another. Where rainfall is high or continuous the gum may be washed away or spoiled soon after it is formed. Furthermore under such conditions the actual secretion of gum is likely to be much less than when the trees grow under drier conditions. Some of the species referred to will grow and thrive under a wide range of conditions or in both the wet and the dry tropics.

Bombay is the important gum centre of India both from the point of view of export trade to other countries and of internal Indian trade. According to CAIUS and RADHA gums are received at Bombay from more or less all parts of India, but particularly from Cawnpore, the Central Provinces—Jubbulpore, Nagpur, Amraoti, Rajputana, Punjab, Sind, Cutch, Kathiawar, East and West Khandesh, Gujerat and the Western Ghats. "The wholesale dealers in gums reside in that part of Bombay known to the general public as 'Danabunda', an unmapped locality situated within the Mandvi area. There the trade is quietly but efficiently carried out by Gujeratis, Jain Banias, Kutchis, and a few Mohammedans; all of them remarkable for the courtesy of their manners and their readiness to oblige. There too, in Samuel Street, is the seat of the 'Bombay Gum Merchants' Association".

The Association was founded with the object of promoting feelings of goodwill among the gum merchants, and of encouraging the trade by looking after the general interests of the dealers. 'The Association will strive to settle disputes and debatable points, and will hold correspondence with the authorities and other public bodies and institutions with the object of promoting the general good of the merchants. It will also discuss matters relating to the general good of the country and, when occasion demands, will raise and manage funds in this connection.'

Not all the gum merchants, however, are members of the Association; a fact of general significance since the members, though allowed to import or export gums, are not permitted to trade in 'katcha' gums, that is the unsorted raw material. Members of the Bombay Gum Merchants' Association may only trade in 'pakka' gums, that is graded gums obtained after the cleaning and sorting of the raw material.

No restriction of any kind is put on the trade of the non-members who deal indifferently with the so-called 'katcha' and 'pakka' materials. They receive the raw products from various parts of India, hold a sort of private auction sale at their own godowns or shops, and dispose of the stuff to the members through brokers.

On reaching the godown the large dirty masses of 'katcha' material are first broken and cleaned by men. The broken stuff is then passed on to women, especially noted for their patience and industry, whose duty it is to sort the pieces according to size and colour. The finished product is labelled, its price fixed, and then—and only then—is the merchant, member of the Association, allowed to put the gum on the market for sale."

With regard to the retail gum trade in Bombay CAIUS and RADHA state—"Most of the local dealers, generally grocers, buy their stock according to need from the wholesale merchants at Danabunder. A few deal directly with firms in Gujerat, Kathiawar, Cawnpore, East Khandesh and Thana Districts; or with collectors in villages of the Deccan and the Western Ghats. Others again procure their goods from the Gonds, Bhils, Katkaris or other hillmen, who visit the city occasionally and whose occupation is to collect gums from the trees of the forests. . . . As a rule, the men behind the counter give the goods for what they are. They all readily admit that no article is the genuine 'gum bavul' or 'acacia gum'; but a mixture of this with such other gums as Kher, bel, lemon, neem, gonda, etc. Nevertheless, the 'bavul gond', owing to its colour and size and the presence of numerous fissures, is always recognizable and, should necessity arise, could be picked out from the mixture and supplied to the customer.

For the one thing that matters is to please the customer and meet his requirements. The uses to which the gum is put are indeed, so very numerous and variable, that the merchant has to keep a large number of assorted grades to be able to satisfy the needs of his clientele. Hence the equally long list of vocables under which the commodity is sold!—*gundar, babool, dink, katila, ghati, makali, dhavda, dhavdi* or *dhavli, kadala* or *karaya, kani babool, deshi babool, bambul, arabi gond, safed gundar, kher, lal gundar, gorad gond, etc.* The gum is used by mill-owners in the finishing of cloth and paper. It is also employed in the match industry and in the preparation of water colours, inks, varnishes, and paints, and in calico printing. Mixed with lime, mortar and cement it finds its way into house building operations. As an adhesive, gum arabic is used in the preparation of wigs, paper kites, clay toys; and there is a very heavy demand for it at the time of the Ganpat festival. A fairly large amount is also needed for the manufacture of the various cosmetics more abundantly required on festive occasions" (Caius and Radha).

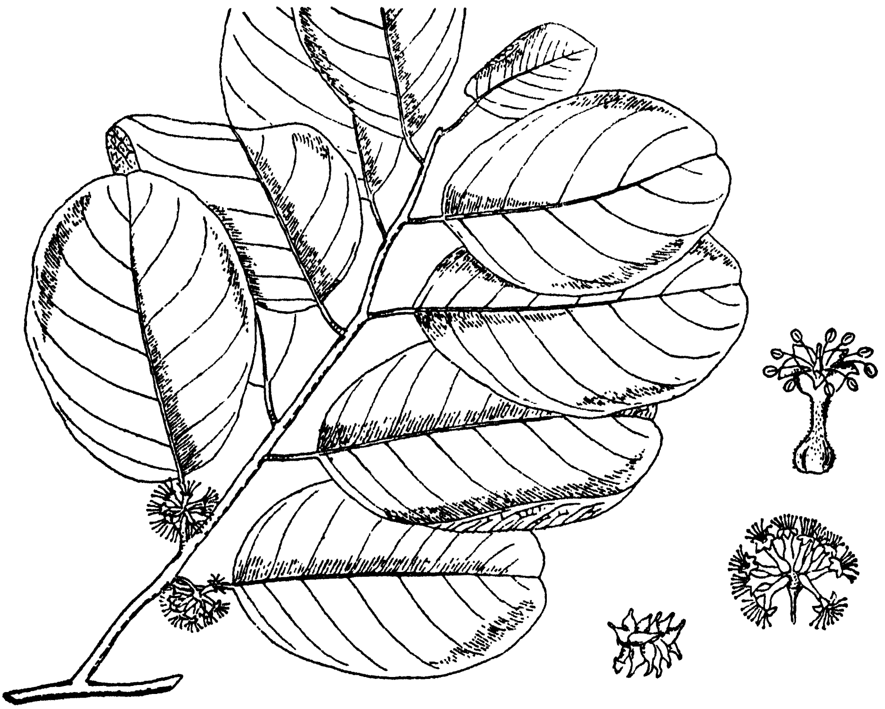


FIGURE 10.—**Anogeissus latifolia** Wall. The main source of Indian "gatty" or "ghati" gum.

"Gum ghati" or "gatty gum" is a somewhat loosely used term for a class of gum which is much used in India and which has been exported to British and other markets in the past. In European commerce the term "gatty gum" is usually used for any highly viscous gum of Indian origin. Such gums are believed to be derived in the main from *Anogeissus latifolia.* In India and on the Bombay markets the term "ghati" gum is said to be very confusing. Some dealers apply it to any mixture of gums, while others restrict it to gums imported from the Western Ghats. Still others maintain that true "ghati" is derived from *Acacia catechu.* It is sold under two forms on the Bombay markets, the one a superior kind used for edible purposes and the other an inferior sort usually powdered and used as an adhesive in whitewashing.

The following are brief accounts of the more important Indian or Asiatic gums and of their botanical sources:—

Aegle marmelos:—Bael or bel fruit, a well known and important fruit tree throughout India. It is much cultivated and also occurs in the wild state—in the dry forests. The wild form differs from the cultivated in leaf characters, in the presence of spines, and in having a much smaller fruit. Two distinct types of gum or "gummy" substance are yielded by the tree, and ordinary gum from the trunk and a gum-like substance from the pulp of the fruit. The latter is most noticeable before the orange-like fruits are fully ripe. The pulp is eaten and is also much used in India in making a kind of sherbet and as a conserve. It is also valued for its medicinal properties, in diarrhoea and dysentery. On account of its mucilaginous nature it has been considered as a substitute for quince seed, hence the name "Bengal quince" that has been used for it. The fruits may be sliced and dried and in this form are often to be seen in the bazaars. It may be used alone, as an adhesive, or mixed with lime as a sort of cement. According to some writers (BURKILL) it has been used as cement in wells for it sets hard and is not affected by water. Jewellers in Ceylon are stated to have used it as a cement and the fruit cut, not emptied of its content, to be used as a gum-pot in offices in Siam. Mixed with other substances it is used in the construction of some of the buildings of the Laos and the Siamese. According to DYMOCK, WARDEN and HOOPER this "gum", in the dry state, is quite insoluble in water, but dissolves in strong alcohol and should therefore be considered as a resin rather than a gum.

Albizzia lebbek:—The "East Indian Walnut" or "Siris" is another of the well known trees of India and is important for timber. Not only is it common as a forest tree in most parts of the country but is also cultivated as an ornamental tree, especially for avenues. As a shade tree it is now in use in many parts of the tropics. Gum may exude freely from the tree, often drying in stalactiform masses and varies in colour from light yellow to deep reddish brown. The gum is sometimes imperfectly soluble. According to CAIUS and RADHA it may appear on the Bombay markets in a pure state, unmixed with other gums. Samples of "gum shiraz" and "gum mamrah" on the Bombay markets were also considered to be mixtures of the gum of this species and of *Albizzia odoratissima.*

Albizzia odoratissima:—This small deciduous tree occurs wild on the lower slopes of the Himalayas and in northern Burma and extends southwards to Ceylon and Siam. The gum generally appears as large, amber coloured, transparent tears, superficially fissured. It is not wholly soluble. CAIUS and RADHA refer to samples of "gum khota" from the Bombay dealers, used for edible purposes, which were considered to be mixtures of the gum of this species and of *Albizzia stipulata* and *Cedrela toona.*

Albizzia procera:—The "white siris" with its smooth whitish bark is a conspicuous tree in Indian forests and very like *A. lebbek.* "The trunks of trees growing in the neighbourhood of Bombay are often covered with numerous granular or warty masses of gum about half an inch in diameter; occasionally the gum exudes in small tears and vermiform pieces. It is of a reddish brown colour, transparent and polished in appearance when fresh, but becomes dark and opaque on keeping. The freshly exuded gum completely dissolves, yielding a thick, slightly gelatinous mucilage, but the dark, opaque gum is imperfectly soluble" (Dymock, Warden and Hooper).

✓ **Albizzia stipulata:**—This fast growing Indian tree is said to yield a dark coloured gum which is not wholly soluble. The gum is known to be one of the constituents of the "Gum khota" of the Bombay gum merchants and is said to be used by the Nepalese for sizing their "Daphne" paper.

Aleurites moluccana:—The "candle nut" tree is a native of the Malay Archipelago but is now much cultivated throughout the tropics as an ornamental tree. In some instances it has become naturalized. The seeds are rich in oil which is extracted and used in some places. Gum frequently exudes from the trunk and is sometimes collected. It is usually light coloured and without taste or smell, is partly insoluble and swells considerably with water.

Anogeissus latifolia:—This common Indian tree is to be found in most of the dry, deciduous forests of India, and also in Ceylon. Its grey bark and the fact that the leaves turn red in the dry season make it conspicuous. The tree produces gum freely and is also the source of a useful timber and tanning material obtained from the leaves. It is the main source of the "gatty" or "Indian gum" that reaches European and American markets. The gum of this tree generally occurs in rounded tears .5-1 cm. in diameter, or larger vermiform pieces. The colour is usually light yellow but varies from almost colourless to brown. The gum has a glassy fracture and is transparent internally although the surface is usually dull white, roughened and opaque. Its rather marked physical characters make it distinguishable from other gums with which it may be mixed. On keeping through the monsoon season the gum darkens and becomes agglutinated into masses. A feature of the gum is its high viscosity, about double that of gum arabic. The finer qualities form a more or less colourless mucilage with only a faint characteristic odour and are claimed to be well suited for pharmaceutical purposes as they form an excellent emulsifying agent, one part of the gum being used in place of two of ordinary gum arabic (Br. Pharm. Codex 1934). The gum has long been used in India both for pharmaceutical purposes and in calico printing. It is often sold in the pure state in the Bombay gum markets (Caius and Radha).

Bauhinia spp.:—Several of the arboreal species of *Bauhinia* are known to be worked for gum in India, including *B. retusa, B. purpurea* and *B. variegata,* all well known trees. While the gums may be of attractive appearance, clear and light in colour, they appear to be only partly soluble in water with which they form gelatinous masses. They are, however, used locally for edible and for other purposes. The gum of *B. retusa,* which is collected by natives in the neighbourhood of Dehra Dun and adjoining regions was found to resemble gum arabic in some of its properties but to be more like tragacanth in its behaviour to water. It was considered by brokers to be of low commercial value (J. S. Gamble 1922).

✓ **Buchanania lanzan** (syn. *B. latifolia*):—This tree occurs in the dry forests of India and Burma and is noted for its edible kernels which resemble Pistachio nuts and are sometimes called Cuddapah almonds. They are often made into native sweetmeats. Both pale and dark coloured gums from this species are in the Kew museum ("pial" or "peal" gum). The tears are large, clear and vitreous but the gum is not wholly soluble. It is said to be suitable for dressing textiles and is used medicinally. According to Kirtikar and Basu in the Madras Presidency the gum is mixed with goats' milk and given internally for intercostal pains.

Cedrela toona:—The red cedar or "toon" tree of India is well known for its reddish open grained wood, much used for furniture and other purposes. It is widely distributed in the wild state and is also cultivated. The gum may occur as smooth, transparent, stalactiform masses, yellow or yellowish brown in colour. It is only partly soluble, the insoluble portion increasing with age. According to Caius and Radha it may appear in the pure state on the Bombay markets or form part of "gum khota".

Chloroxylon swietenia:—The wood of this species constitutes the satinwood of commerce, the tree occurring in Ceylon and in central and southern India. Gum from the tree occurs as amber or brownish coloured tears or rod shaped pieces which swell in water forming a gelatinous mass, only a portion being soluble. This gum has also been purchased in a pure or unmixed state from Bombay merchants.

✓ **Delonix regia** (syn. *Poinciana regia*):—The "flamboyant" or "flame tree", so-called on account of its brilliant red flowers, is a native of Madagascar but is now extensively cultivated throughout the tropics: also in the sub-tropics, *e.g.* Durban, Natal. In many parts of Asia it is favoured as an ornamental tree, especially for streets and avenues. It yields a yellow or reddish brown gum in irregular or warty tears. This is soluble in water and forms a thick opalescent mucilage.

Elæodendron roxburghii (syn. *E. glaucum*):—A high quality gum is known to be obtained from this tree which occurs throughout the greater part of India. Tears may be large or small with a finely fissured surface and the colour varying from almost colourless to reddish brown. It is readily soluble in water forming a clear, strongly adhesive and tasteless mucilage.

Feronia acidissima (syn. *F. elephantum*):—The wood-apple is, like its relative *Aegle marmelos,* a wide-spread fruit tree in the eastern tropics and occurs both wild and cultivated. In the wild state it is found mainly in dry open forests. The fruit is used in much the same way as that of *Aegle* but is not gummy or mucilaginous. The tree yields gum abundantly on the trunk or branches and this is collected a good deal. It is a fine quality gum, completely soluble in water, and resembles gum arabic in its properties. Often it is present in the "bavool" gum (mainly *Acacia arabica*) sold by Bombay gum merchants (Caius and Radha). The gum has been studied in detail by Lemeland. It usually occurs in small, irregular, rounded tears, perfectly transparent, which vary from colourless to reddish amber. Sometimes the tears are large and the gum has a tendency to agglomerate into masses. The paler samples form a thick, colourless, tasteless, mucilage. It is regarded as one of the most valuable of the many gums collected in India, where it is put to the same uses as gum arabic. In native medicine it is said to be preferred to gum arabic or Acacia gum. In Java the gum is used in making ink (K. Heyne 1927). It is more viscous than gum arabic and not inferior in adhesive properties.

Lannea grandis (syn. *Odina wodier*):—This tree ("gingan") occurs wild in the dry forests of most parts of India, also in Burma, Siam, Indo-China and Ceylon and is valued for its heart wood. It is also freely cultivated elsewhere, *e.g.* Java, especially as an avenue tree. The tree yields a good quality gum which is sometimes obtained by tapping (Gamble) but more often from natural exudation. Tapping, carried out by making short cuts in the bark, causes knobs or malformations to develop on the trunk. Frequently the gum exudes as a result of a boring larval insect in which case it may be fouled by the excreta from the insects' tunnels. Tannin from the bark may contaminate the gum (Burkill). The best quality gum from the tree, obtained by tapping, is light coloured and in irregular, rounded or angular pieces. These are sometimes quite large and brittle or friable from the presence of numerous cracks. The gum dissolves completely in water and forms a somewhat glairy though tasteless mucilage with good adhesive properties. It is very similar to gum arabic. In India it has been used in calico printing and as a paper size in Nepal.

Mangifera indica:—The mango tree, which is wild in India and universally cultivated in the tropics and subtropics, sometimes exudes a gummy substance from the stem. Actually this is partly resinous and only about a third of the gum is soluble in water. It is of a variable nature, has a dull fracture and is reddish brown to black in colour. The gum is sometimes sold in Indian bazaars as a substitute for gum arabic (Watt) and probably used for edible purposes.

Melia indica (syn. *Azadirachta indica*):—The "neem" or "margosa" is one of the best known trees in India and is also common in Java and elsewhere. It is best suited for the drier areas and in these gum may be produced very freely (Heyne). In wet climates the gum is liable to be washed away or spoiled before it can be collected. The gum usually forms in large, clear, light coloured tears or in vermiform pieces. These are commonly cracked or fissured on the surface. The colour is usually pale yellow to amber but may darken to brown with age. In water the gum dissolves freely but is inferior to gum arabic in adhesive properties. It has been purchased in the pure state on the Bombay markets (Caius and Radha).

✓

Prosopis spicigera:—This medium sized thorny tree of the arid regions of northern India is a close ally of the American mesquite, *Prosopis juliflora* (*see* Chapter V). It often grows gregariously and is the main fuel tree of the Punjab. On account of its enormously long tap root, which has been measured and found to be as much as 84 feet long and penetrating vertically 64 feet (GAMBLE), it is able to exist under conditions of extreme aridity. Gum exudes from the stumps of cut stems and branches and from other wounds. It is described as—"unusually friable, occurs in small angular fragments of a yellowish colour, more or less deep, sometimes in large ovoid tears about two inches long, of an amber colour internally, but having a frosted or candied appearance externally from the presence of numerous minute cracks which cause the tears to crumble under pressure. With water it forms a rather dark coloured tasteless mucilage of about the same viscosity of gum arabic (DYMOCK, WARDEN and HOOPER).

Sesbania grandiflora:—This small soft wooded tree is much cultivated throughout the eastern tropics, and is also to be found in Mauritius and northern Australia. The tender leaves, pods and flowers are eaten as a vegetable and in curries. According to A. P. WEST and W. H. BROWN it produces in the Philippines "a clear gum used locally as a substitute for gum arabic". In India the gum has been described as "resembling Kino, of a garnet red colour when fresh, but becoming almost black by exposure to the air" and as being "partially soluble in spirit and also in water, leaving a gelatinous residue of small bulk. It is very astringent (WATT).

Spondias spp.:—Gum is produced in greater or less degree by various species belonging to this genus, some of which, like *S. cytherea* (Otaheite apple) and *S. pinnata* (syn. *S. mangifera*) are cultivated fruit trees of the tropics. The last mentioned occurs in the wild state from India to the Moluccas. The gum is yellow or reddish brown and often in smooth stalactiform pieces. It forms a gelatinous mucilage with water and is not wholly soluble. Specimens of this gum in the Kew Museum are very dark (brownish black), possibly through age, and in large irregular pieces.

Terminalia spp.:—Several trees belonging to this genus yield gum. One of the better known is *T. belerica,* which is widespread in the forests of India, Burma and Ceylon at the lower elevations. The gum is usually dark with a smooth surface free from cracks. With water it swells forming a tough, gelatinous mass, very little dissolving. Crystals of calcium oxalate are sometimes present in the gum. These doubtless originate from, or have been carried out of the bark. The gum is sold in bazaars in India (BURKILL).

Chapter V

GUMS OF THE NEW WORLD

In view of the extent of the Americas and the extremely varied nature of their climates and their vegetation it is perhaps surprising that so few gums have up to the present attracted much attention or become of any commercial importance. These may almost be numbered on the fingers of one hand. This is in strong contrast to southern Asia and to Africa where the number of species that yield serviceable or commercial gums is large. Many hundreds of the woody species in North, Central and South America do yield gum to a greater or less degree but usually secretion is not pronounced and collection of the gum for local use or for export is rare. The few species that have been exploited to a small extent for gum in the past are for the most part leguminous, belonging to the genera *Caesalpinia, Piptadenia,* and *Prosopis.*

South America:—In the Argentine *Caesalpinia praecox,* commonly called "brea", is known to have been a source of gum for many years. This small tree occurs mainly in the north west provinces of the Argentine—Mendoza, San Juan, Rioja, Santiago del Estero, Tucuman, Cordoba, etc.: also in Chile. The tree bears pinnate leaves and is not unlike some of the smaller Acacias in general appearance. The gum ("gum brea") is secreted during the period December to April and is collected either as stalactiform, irregularly shaped pieces which may be as long as 8-15 cms. or as tears 2-5 cms. in diameter. The former are generally reddish yellow in colour, bright and transparent, and break with a conchoidal fracture. Sometimes the tears are fused together in masses and mixed with pieces of bark. When the gum is freshly exuded and has not had time to solidify it is of a golden yellow colour with a sweetish taste. On solidifying a pink or darker shade may develop and the gum becomes very hard and difficult to pulverize. It is generally completely soluble in water and forms a viscous although slightly acid mucilage which is said to compare well with true gum arabic (DE CORDEMOY).

There are over 125 species of *Caesalpinia.* These occur in both tropical and subtropical countries, some species being very widely distributed and almost cosmopolitan in the tropics. The majority are small trees or shrubs, too small to be of use for timber, but in some instances of value as sources of tanning material (*e.g.* "divi-divi" *C. coriaria*). It is possible some of the other South American representatives of the genus may yield useful soluble gums resembling gum arabic in their properties.

The genus *Piptadenia,* which consists of more than 50 species widely distributed in the tropics, is especially well represented in tropical America and some of those that occur in Brazil and Argentina are known to yield gum in fair abundance. In Brazil the name "angico" is commonly used for representatives of the genus, some being well known for their timber. One of the best known species is *Piptadenia rigida* of southern Brazil and northern Argentina, and one of the sources of "angico" gum. This tree reaches large dimensions and may be 100 feet in height with a bole some 4 feet in diameter and unbranched for the first 50 feet. It bears a wide spreading crown. The leaves are doubly pinnate with numerous fine leaflets, the flowers inconspicuous and the pods thin with scalloped margins. The wood is used in heavy construction and for fuel. Among the common names recorded for the tree are—angico, angico vermelho, angico verdadeiro (Brazil): angico, angico colorado, anchico colorado, and curupay-ra (Argentine) (RECORD and MELL 1924). According to DE CORDEMOY the gum from this tree is amber coloured and in angular or globular fragments. The gum breaks with a clean vitreous fracture and sometimes small bubbles of air are present in the interior. The gum may be mixed with woody matter or fragments of bark. It is freely soluble in water and gives a more or less tasteless and odourless mucilage with good viscosity—said to be intermediate between that of Sudan and Senegal gum arabic. Except for colour the gum is similar in general properties to gum arabic.

Piptadenia cebil is another Argentine species of the genus well known as a gum yielder. It occurs in north west Argentina in much the same areas as those recorded for *Caesalpinia praecox*. It is also known to occur in the provinces of Catamarca, Tucuman, Salta, Charco and Corrienties. The tree reaches 60 feet or more in height and has bipinnate leaves and white flowers in globular heads. These are followed by leathery pods 5-8 cms. long each with 8-11 seeds. Common names for the tree are "cebil", "cebil colorado" and in Brazil "angico rosca" (M. P. CORREA 1926). The gum is often produced in abundance and may form large tears. In the collected gum angular pieces are also present, sometimes of a dark colour and mixed with impurities. With the better quality gum the tears are yellow or reddish yellow and weigh 4-10 gms. They are often dull or frosted outwardly owing to the presence of minute superficial fissures. Sometimes a tear consists of distinct parts, a dull superficial fissured layer which easily disintegrates, surrounding a hard or vitreous core in the centre of which there may be a cavity. The gum is not easily pulverized but readily dissolves in water, the only residue being the external impurities present in the gum. It possesses good viscosity and good adhesive properties, comparable with those of gum arabic. The colour of the mucilage is yellow or reddish yellow and the reaction slightly acidic (DE CORDEMOY).

In the latter part of the last century when ordinary gum arabic was in short supply owing to rebellion and political unrest in the Sudan and the consequent dislocation of the country's commerce, a certain amount of so-called "Brazilian gum arabic" appeared on the London markets. At the time the botanical source of this gum was not known but steps were taken at Kew to obtain this information. The British Consul at Para was approached with a view to obtaining herbarium specimens of the plant or plants concerned. (*see* Kew Bulletin 1888:128-9). He replied that the gum in question was not a product of his district but was found in considerable quantity in the province of Piauhy and was shipped from Parahyba to Para (Belem) for transhipment to Britain. The tree yielding the gum was said to be known as "angico" and the gum to be of a reddish colour "oozing out by cutting the bark" and to be soluble in water and considered a substitute for gum arabic. From specimens that were received at Kew later it was apparent that the tree in question was *Piptadenia macrocarpa.* It is now known that a gum or gum-resin is often produced freely by this species, commonly called "angico do Campo" in Brazil. *Piptadenia colubrina* ("angico branco") is another well known gum yielding species in Brazil (CORREA).

Cashew or "acajou" gum, a product of the cashew nut tree (*Anacardium occidentale*), a native of eastern South America and the West Indies but now widely distributed in the tropics, has claimed a certain amount of attention. The tree is of interest in that it appears to have been one of the first tropical American trees to have been introduced to other parts of the tropics by the early Portuguese explorers. They are said to have been particularly fond of the nut themselves and to have introduced the tree to India (Goa), Malaya and elsewhere. The tree is anything but exacting in its requirements and grows well under dry conditions and in poor soils unsuited for other crops. It has now become extensively naturalized, particularly in parts of East and West Africa (Accra Plains) and on the west coast of India. In the latter country it is to be seen apparently wild, and cultivated, and is the basis of the important cashew nut export industry that has developed in more recent years. Most of the kernels produced have been exported to the United States, whose import of cashew kernels rose from 50 tons in 1923 to 11,000 tons in 1935 and 13,000 tons in 1938 (V. E. YARDSLEY 1945). The fruit has other uses apart from its oleaginous palatable kernel. The juicy pear-like pedicel is eaten and made into beverages of various kinds, both alcoholic and otherwise. Particularly is this the case in Brazil where the tree ("cajueiro") and its fruit are held in high esteem. The irritant tar-like oil from the shell of the nut, due to the presence of cardol (10%) and anacardic acid has medicinal uses and is employed as a preservative against insects for woodwork, books, etc. This cashew nut shell oil has now become an important raw material for phenolic resins with special properties valued in electrical work (see page 155). It is believed the irritant substance may also be present in other parts of the tree and possibly even in the gum to some extent.

Gum is sometimes produced very freely by the tree and solidifies either as tears or stalactytic masses. The latter are sometimes abnormally large, as thick as a man's wrist. It would seem that gum is not always produced freely by the tree for Heyne refers to plantations established at two localities in Java to test the yield of gum but which produced no gum! From specimens at Kew from various parts of the world it is apparent the gum varies much in colour from very pale yellow to reddish or dark brown.

It is not entirely soluble in water and dissolves much more readily in hot than in cold water and forms a slightly glairy, more or less turbid mucilage. The turbidity is considered to be due to small quantities of a yellowish oily body which may be detected with the microscope. It has quite good adhesive properties and has been used for stationery and in bookbinding. When used for the latter purpose it is considered to act as a repellent to insects, due possibly to the oily body referred to. The gum has appeared in commerce in the past as "Cashew gum" but not regularly. Other species of *Anacardium* known to produce gum in Brazil are *A. humile* and *A. nanum.*

An interesting gum from Chile is that known as "chagual", obtained from species of *Puya,* especially *P. chilensis,* but also *P. lanuginosa, P. lanata* and possibly other species (VON WIESNER). The genus *Puya* consists of some 40-50 species of large terrestial Bromeliads of a xerophytic character that occur mainly on the slopes of the Andes in Chile and in other parts of South America. *Puya chilensis,* from Chile, is probably the best known species and is sometimes cultivated as an ornamental or a stove plant in other countries. It is of striking appearance, not unlike a *Yucca* with a stem up to four feet or more in height (sometimes branched) at the end of which is the cluster of leaves. These are glacous and sword-shaped, two to four feet in length with stout marginal spines. These point forward in the upper part of the leaf and backwards in the lower, giving the plant a formidable appearance and suggesting value as a fence or barrier plant. The large, greenish yellow flowers, 2 inches across are on a hoary, branched infloresence supported on a long upright stalk 3-5 feet long. In Chile the plant is called "puya" or "cardon". The soft material of the stem is sometimes used for corks and bungs and the leaf spines as fish hooks.

The interest attached to "chagual" gum is that it is produced by the plant as a result of insect attack (larvæ of *Kastnia* (*Castnia*) *elegans*) and appears in a characteristic form, *i.e.* fragments of a hollow cylinder. These vary from .2-1.5 cms. in diameter and often bear a clear impression on the inner or concave side of the surface of the plant on which the gum was formed. Globular or stalactytic pieces of the gum also occur. The gum is generally of a clear yellow colour but may be dark. It is seldom opaque. It breaks with a conchoidal fracture and its hardness is about the same as that of gum arabic. It is only partly soluble in water but the solubility, like the colour, varies with different samples. The insoluble portion forms a clear jelly. In this respect, therefore, the gum resembles those of the gum tragacanth group.

Central America:—In Central America and particularly in Mexico several of the *Cactaceae* are known to produce gums, which are sometimes collected for local, domestic use, but so far none of these gums appears to have become of any commercial importance. Not all the *Cactaceae* produce gum or possess a gummy or mucilaginous sap. It is mainly those that have a woody stem or a woody skeleton in the stem that are of interest in this connection, especially some of the Opuntias. The gum appears to be absent in the fleshy or non-woody *Cactaceae* which generally have a thin watery sap. This is in fact even used as drinking water in some instances. A lustrous transparent gum of whitish or yellow colour commonly forms on the stems of Opuntias. It is only partially soluble in water and does not appear to owe its origin to pathological causes or insects as is the case with many gums, but to be a natural physiological exudation. Among Spanish speaking peoples it is known as "alquitron de tierra" and is also called "nopales gomenos" (L. DIGUET 1928).

The gum is sometimes mixed with other substances and used as a masticatory by the indigenes. It is also mixed with fat in making cheap candles which resemble those made from beeswax. Apart from the hardened gum the gummy sap, easily extracted by crushing the fleshy tissue, also has uses. It was formerly employed in popular medicine or concentrated over a fire and mixed with inert substances forming a sort of mastic or used as a sort of adhesive for sticking together pieces of wood, etc. A tarry substance was also obtained in this way, used in earlier days by Spanish sailors as a caulking compound for their ships.

Lemaireocereus hollianus, a common cactus in the south of Puebla in Mexico and used as a barrier plant on account of its easy culture and upright habit, is said to produce a gummy or mucilaginous product very freely (DIGUET).

In Venezuela the following gums are recorded "goma de cardon" from *Cereus* sp., "goma de guamacho" from *Pereskia* sp. and "goma de tuna" from *Opuntia ficus-indica* (VON WIESNER). The gum of the last mentioned, a species now widely naturalized in other parts of the world, is described as resembling tragacanth in that it is mostly insoluble in water but swells to a jelly-like mass and has the remains of parenchyma cells present in it. It often shows crystals of calcium oxalate, tannin and colouring matter.

It is interesting to observe that gum from *Opuntia* has attracted attention in countries outside the natural habitat. An Indian observer states that "a good clean mucilage" with excellent adhesive properties may be obtained by cutting across the immature fruits of prickly pear. In India certain species of *Opuntia* have long been naturalized (E. K. KRISHNAN 1939).

Some species of *Pithecolobium* and *Enterolobium,* native to Central and South America, are known to yield gum freely under suitable conditions in other countries. Among these are two well known species—*Pithecolobium dulce* and *Enterolobium saman* (syn. *Pithecolobium saman*), both now extensively cultivated and also naturalized in other parts of the tropics. In English speaking tropical countries the former is often called "Madras thorn," being much cultivated as a prickly hedge and for firewood, especially in India. *Enterolobium saman* is well known as the "rain tree" and much cultivated in many parts of the tropics as a quick growing shade tree. According to DYMOCK, WARDEN and HOOPER gum of *Pithecolobium dulce,* collected in India, is usually in transparent, spherical tears about half an inch in diameter and of a dark brown colour. It is freely soluble in water. The gum of *Enterolobium saman* is also dark but not freely soluble, swelling in water into tough cartilage-like masses. Although an introduced tree in India its gum has been purchased both in a pure state and mixed with other gums on the Bombay markets, according to CAIUS and RADHA. In Venezuela *Pithecolobium hymenaefolia* yields a gum known locally as "goma de orore" and *Enterolobium cyclocarpum* one called "goma de caro". The latter is reputed to be dark, to be only partially soluble (VON WIESNER), and to be employed in Sinaloa as a remedy for bronchitis (RECORD and MELL).

Another well known central American tree cultivated elsewhere which may yield gum abundantly is the Cuban or Spanish mahogany (*Swietenia mahagoni*). In India, where the tree was first introduced in 1795, gum runs down the trunk of the tree drying into white shining fragments which become darker on keeping. The gum is freely soluble and has also been recorded by CAIUS and RADHA from the Bombay markets as being sold in both the pure state and mixed with other gums. Other trees of Latin America or the West Indies whose gums have attracted attention at different times in the past are *Spondias dulcis, S. lutea, Picraena excelsa* and *Quillaja smegmadermos* (VON WIESNER; DE CORDEMOY).

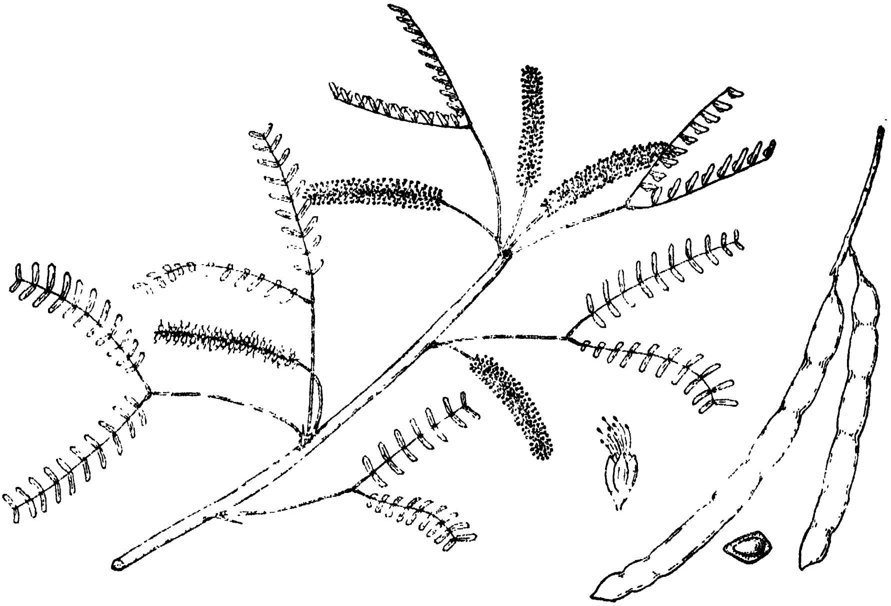


FIGURE 11.—**Prosopis juliflora** DC. (mesquite). The gum has been used as a gum arabic substitute in the United States.

North America:—The most important gum yielding species in North America is the mesquite, *Prosopis juliflora,* and its varieties. This spiny shrub or small tree is a characteristic feature of the vegetation of many of the drier parts of the south western United States and extends southwards being common in parts of Mexico and the West Indies. It has been introduced to many other countries and is valued on account of its ability to withstand the driest of conditions and the food or forage value of its pods and young shoots. The tree was early introduced to Hawaii where it has become extensively naturalized and well known. It was subsequently introduced as a fodder tree to some of the arid or semi-desert regions of Australia, India, Africa and elsewhere.

The mesquite is one of those interesting species that are valued in some areas or some countries but considered a pest in others. For in some of the south western ranges of the United States, particularly Arizona, New Mexico and Texas it has become increasingly abundant in recent years. This has resulted in a great reduction in the actual grass pasturage and where thickets have become very dense ranges have actually been abandoned on account of the difficulty in gathering and moving the cattle. However even in these areas the mesquite is regarded as valuable, if controlled, for it is useful in preventing soil erosion with its extensive root system. It also supplies fuel wood and lasting fencing posts where other timber is scarce. The tree has other minor uses. The flowers are a valued source of nectar and honey in beekeeping. The seeds ground into flour were used by Indians and white settlers alike for bread, being one of the staple desert foods (L. BENSON 1941).

The mesquite is a variable species and shows wide differences in leaf characters. It is mainly these that are used in distinguishing the established varieties, *e.g.* var. *glandulosa* (large leaflets), var. *torreyana* and *velutina* (very small leaflets). Intermediate forms are common. The size of the shrub or tree varies much with habitat. With the more favourable soil and moisture conditions it may reach 40 feet and have a girth of 4 feet.

Gum is sometimes produced by the mesquite and it is probably these larger trees that are the more favourable for its collection. This gum has long been collected and used in the United States. It is commonly a clear, fairly light coloured gum of good solubility and has been classified as equivalent to the medium or poorer grades of Sudan gum arabic (VON WIESNER). The gum has been used in the United States as a substitute for gum arabic, as an adhesive, and in the manufacture of gum drops. It has been exported from Mexico to the United States (VON WIESNER) but is believed to be unknown in European commerce. Other species of *Prosopis* in South and Central America also yield gum.

Chapter VI

MISCELLANEOUS AND LITTLE KNOWN GUMS

Various gums that may be of local use or interest in the countries in which they occur and which are not covered in the previous chapters are here dealt with. Some of these gums have been investigated at the Imperial Institute in London and elsewhere in the past but it is seldom that any have been found to show promise or have been considered likely to find commercial outlets if available in sufficient quantity and in regular supply.

Adansonia:—The baobab (*A. digitata*), so widely distributed throughout the drier parts of tropical Africa, yields a white, semi-fluid gum from its massive trunk when wounded. This is odourless and tasteless and somewhat resembles gum tragacanth. It is more or less insoluble in water and has an acid reaction. With age it becomes reddish brown. An allied species, *A. gregori,* of north west Australia yields a similar pale gum from the stem which is edible, also a dark red gum from the fruit.

Adenanthera:—*A. pavonina,* a small deciduous tree of India and Ceylon, sometimes yields gum. It is much planted for ornament and for its brilliant red seeds used for necklaces and at one time as gold- and silver-smiths' weights.

Afzelia:—*A. africana,* a common tree in many parts of west tropical Africa and Uganda, especially in savannah forests, may yield gum. This tree ("mahogany bean") reaches 40-60 feet in height and occurs in both savannah and in mixed deciduous forests. It has scaling bark like the plane tree (*Platanus*) and a large woody pod. It yields a valuable mahogany-like timber.

Albizzia:—A number of species in this Old World tropical genus are known to yield gum, apart from the Indian species already referred to (Chapter IV). These include *Albizzia procera* and *A. pruinosa* in *Australia* (J. H. MAIDEN 1901), and *A. amara, A. anthelmintica, A. gummifera* and *A. harveyi* in East Africa or Rhodesia. Albizzia gums are sometimes exuded very freely but are not of a high order as a rule and are prone to be dark and only partially soluble.

Anogeissus:—In addition to *A. latifolia,* the source of much of the Indian "gatty gum" (*see* Chapter IV) of commerce, *A pendula* yields a good quality gum in India (DE CORDEMOY). Specimens in the Kew Museum consist of attractive pale yellow or amber tears. In Nigeria the gums of *A. leiocarpa* and *A. schimperi* "marike" gum (Bull. Imp. Inst.

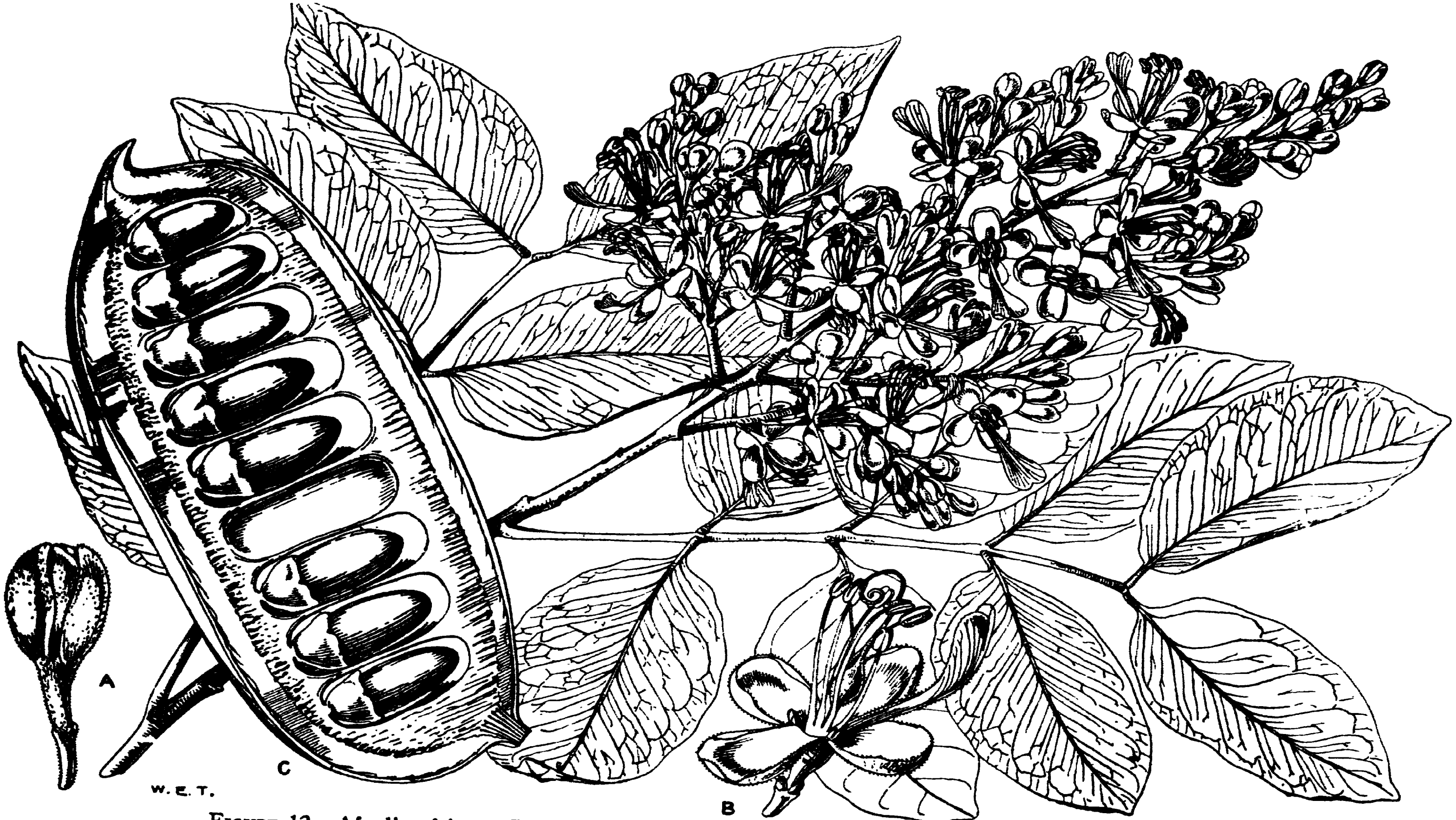


FIGURE 12.—**Afzelia africana** Smith (mahogany bean). A common tree in many parts of tropical Africa which may yield gum. (A, flower bud; B, flower; C. longitudinal section of fruit; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

30:15) have attracted attention in the past and are of fair quality. In northern Nigeria and the eastern Sudan the gum of *A. schimperi* is eaten by the natives, some of whom are stated to regard it as the best gum for chewing (J. M. DALZIEL 1937). It is also used for ink. As collected in northern Nigeria this gum is in large or small fragments, yellow or light brown in colour, with a glassy or weathered suface. The viscosity of the gum is good.

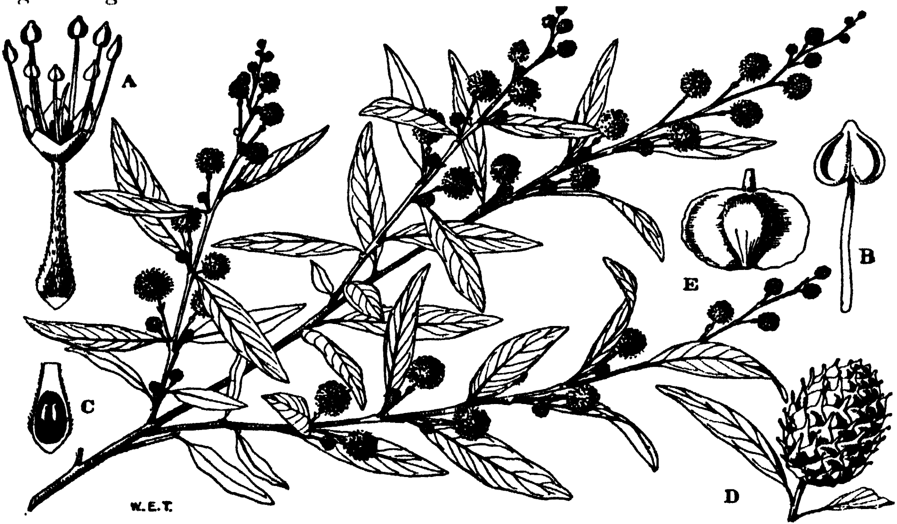


FIGURE 13.—**Anogeissus schimperi** Hochst. The source of "marike" gum in Northern Nigeria, esteemed by natives for chewing (A, flower; B, stamen; C, vertical section of ovary; D, fruiting head; E, single fruit showing wings and persistent base of calyx tube; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Atalaya:—*A. hemiglauca,* "whitewood" or "cattle brush", which occurs in the interior of northern New South Wales and of Queensland exudes a useful pale coloured gum (J. H. MAIDEN 1901).

Balsamocitrus:—*B. dawei,* a little known but interesting Citrus ally from Uganda, contains a gummy substance in the fruits like the Indian bel friut (*Aegle marmelos*). This has been found to be quite water soluble and to resemble gums of the Acacia type but the presence of a volatile oil, giving a characteristic odour, might prevent its use as a gum arabic substitute for many purposes were it available in quantity.

Bauhinia:—The genus is well represented in tropical and subtropical Africa. Among the widespread species in these regions which yield gum are—*B. fassoglensis* and *B. thonningii* (GREENWAY). The gums are not of commercial importance. In Australia *B. carronii,* "Queensland ebony", is reputed to yield a yellow, tasteless gum of good tenacity (MAIDEN 1901). (For Indian species *see* Chapter IV).

Berlinia:—In East Africa *B. eminii,* a tree of the dry forest areas, yields a gum of the insoluble type which has been described as a mixture of gum and kino (VON WIESNER).

Bombax:—The Indian cotton tree, *B. malabaricum,* which is widespread in India in the wild state and is also cultivated there and elsewhere (*e.g.* East Africa), yields a dark opaque gum or gum-resin. This is much used medicinally in India as an astringent in bowel complaints, being sometimes mixed with sugar. It is the main source of the "mocharas" gum of the bazaars. The gum is whitish when first exuded, but darkens to a mahogany or blackish colour on drying and the larger tears are sometimes hollow. *Bombax insigne,* another Indian species, also yields a brown gum.

Borassus:—The borassus palm, *B. flabellifer* and the variety *aethiopicum,* one of the best known palms of the Old World tropics, yields a dark vitreous gum of the insoluble type, probably of little or no value.

Bosistoa:—Gum of *B. sapindiformis* from Mullumbimby, New South Wales, was described as transparent and pale coloured and mainly though not entirely soluble in water. In physical properties it resembled other Australian Rutaceous gums. (MAIDEN and SMITH 1895).

Brachystegia:—Brachystegias are the dominant feature of the woody vegetation in many parts of Tropical Africa. Gum is often exuded by them but is generally dark and obviously of poor quality. This applies to the gum of *B. spicaeformis* in Tanganyika (GREENWAY) and of *B. hockii, B. nchangensis* and *B. longifolia* in Northern Rhodesia, judging by specimens in the Kew Museum collected by Mr. C. G. TRAPNELL. The latter have poor solubility.

Burkea:—Gum from *B. africana* has been investigated. This deciduous tree occurs all over Tropical Africa, chiefly in savannah forests and extends to the Transvaal. A sample received at the Imperial Institute from the Gold Coast consisted of small pale yellow to reddish brown, semi-transparent tears and was regarded as of fair quality but rather dark (Imp. Inst. Rpt., Gums and Resins 153-4).

Capparis:—Gum of *C. nobilis* ("wild lemon") in Australia was found to consist of small particles or vermiform tears, semi-transparent and of a horny texture. In water it was only partly soluble, but swelled to an enormous extent and in general resembled gums of the *Sterculiaceae* (MAIDEN and SMITH).

Careya:—The "patana oak," *C. arborea,* is a well known tree in Ceylon where it is often gregarious on the grassy expanses known as patanas. It occurs also in parts of India and Burma. The gum, like the bark, is astringent.

Cassia:—The commonly cultivated ornamental tree of the tropics, *C. fistula,* well known for its medicinal uses, produces a dark coloured gum only slightly soluble in water. In West Africa the gum of *Cassia sieberiana,* mixed with the pulverized pod, may be applied by natives to sores (DALZIEL). This handsome small tree with its yellow Laburnum-like flower trusses and long pods is common in savannah and open forest areas throughout West Africa and extends to the eastern Sudan, Uganda and East Africa.

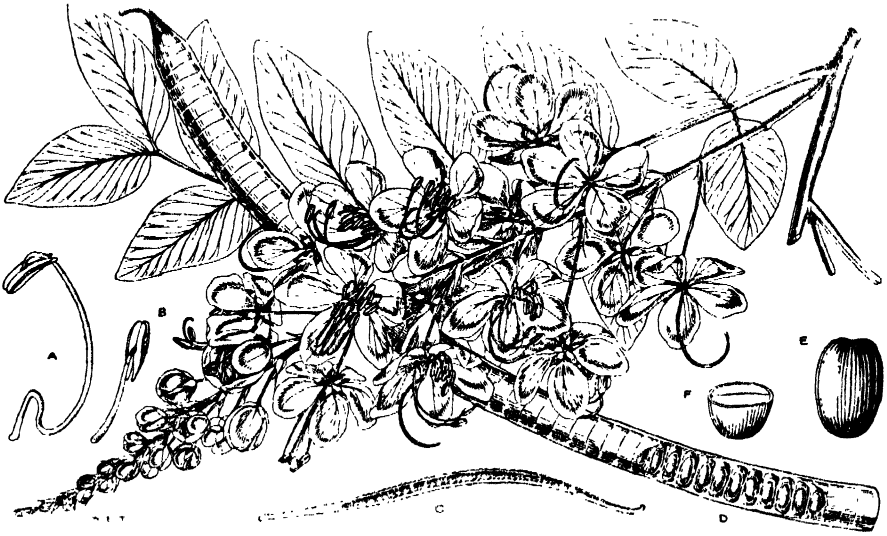


FIGURE 14.—**Cassia sieberiana** DC. A well known tree of the West African savannah with *Laburnum*-like flower trusses. Natives sometimes collect the gum (A, B, two types of stamen; C, longitudinal section of pistil; D, mature fruit; E, seed; F, cross section of seed; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Cedrela:—Gums are yielded by *C. odorata* and *C. australis* as well as by *C. toona.* The first mentioned is widespread in the West Indies and tropical America and the source of the well known fragrant cedar wood. The gum of this species "goma de cedro" is only partially soluble (±25%). A tear in the Kew Museum is abnormally large, measuring some 6 inches in length and 3 inches in diameter. It is dark amber in colour. *C. australis* (Australia) also yields a true gum without any trace of resin (MAIDEN 1901).

Ceiba:—The silk cotton or kapok tree (*C. pentandra*), found in both the Old and the New World tropics, yields a dark gum which is astringent and is used medicinally in India for bowel complaints. The gum swells with water and resembles the tragacanth rather than the gum arabic group except for colour. It has been used as a substitute for katira gum in India.

Ceratopetalum:—This genus is endemic in New South Wales and the gums or gum-kinos as they have been termed of both species (*C. apetalum* and *C. gummiferum*) have been investigated. They are astringent and only partially soluble (MAIDEN 1901).

Chickrassia:—*C. tabularis,* a well known timber tree in India, Burma and Ceylon, yields gum (DE CORDEMOY). Pale and dark coloured specimens are in the Kew collection.

Citrus:—The trees of several of the common Citrus fruits—orange, lime, shaddock, citron—yield gum at times, but nowhere does it appear to be of economic importance. Certain pathological conditions of *Citrus* are associated with gummosis.

Cocos:—Occasionally gum is found on the trunk of the coconut palm (*C. nucifera*), especially when there has been injury of some sort as when a palm falls and in so doing grazes the stem of another. The gum is usually reddish brown. In the Kew Museum there are tears, clear and vitreous, ranging from yellow to almost black. The gum is in the main insoluble in water and swells to a jelly. It has poor adhesive properties and has no regular uses as far as is known.

Cola:—Gum is yielded by *C. cordifolia* in the forests of Uganda according to GREENWAY. The tree is a common one in deciduous and secondary forests of West Tropical Africa where it is known to yield gum (F. R. IRVINE 1930).

Combretum:—This large genus of woody plants, distributed in the tropics and subtropics of both hemispheres, except Australia and Polynesia, and consisting of over 300 species, is well represented in Africa. Several of the African species are known to yield gum freely and often this is attractive in appearance, clear and light coloured, and of good solubility. However, among those so far investigated even the best are inferior to Acacia gum or gum arabic.

Among those that have attracted attention in the past are several from West Tropical Africa such as:—*Combretum dalzielii, C. elliotii, C. ghasalense, C. hypopilinum, C. kerstingii, C. lecananthum, C. sericeum, C. sokodense* and *C. verticillatum*. In the Niger basin, south of 14°N., *C. dalzielii* is said to provide much of the gum collected, but the tree is not tapped. *C. elliotii* is believed to be the most abundant gum yielding tree in Sokoto Province, Nigeria. The gum is used in food, by leather workers, and in making ink. *C. lecananthum* also yields gum ("chiriri" gum) freely in Nigeria in the hot season, which is eaten by the natives. Gum believed to be from this species was reported on by the Imperial Institute as a fairly good soluble gum, although dark, of satisfactory viscosity but difficult to sell in England. *C. sokodense* is reputed to be the source of some of the "mumuye" gum of Northern Nigeria and often appears in smoky, tinged lumps. The gums of at least two species of *Combretum* (*C. hypopilinum* and *C. verticillatum*) are stated to be used by natives in Nigeria to plug carious teeth (DALZIEL).

Among the East African species that have been recorded as gum yielders are the following, which occur mainly in the dry forests and low rainfall areas:—*C. apiculatum, C. binderianum, C. frommii, C. gueinzii* subsp. *splendens, C. longispicatum, C. purpureiflorum* and *C. zeyheri* (GREENWAY).

Cordia:—Some species yield gum in India, *e.g. C. macleodii, C. myxa* and *C. rothii* (WATT).

Cordyla:—*C. africana,* which is a large tree occurring throughout Tropical Africa and extending south to Natal, exudes a gum-resin used to make a sort of size or whitewash for houses in West Africa (DALZIEL). The gum is also collected in the Sudan as "chiraya" or "da" gum.

Corypha:—A brownish black gum is sometimes yielded by the talipot palm *C. umbraculifera,* while *C. utan* may produce a reddish brown sweet smelling gum used medicinally by the Javanese and held in high esteem by them, probably on account of its rarity (HEYNE 1927).

Cratæva:—*C. adansonii,* a tree of the savannahs of East and West Africa, and often stunted through grass fires, is known to yield gum.

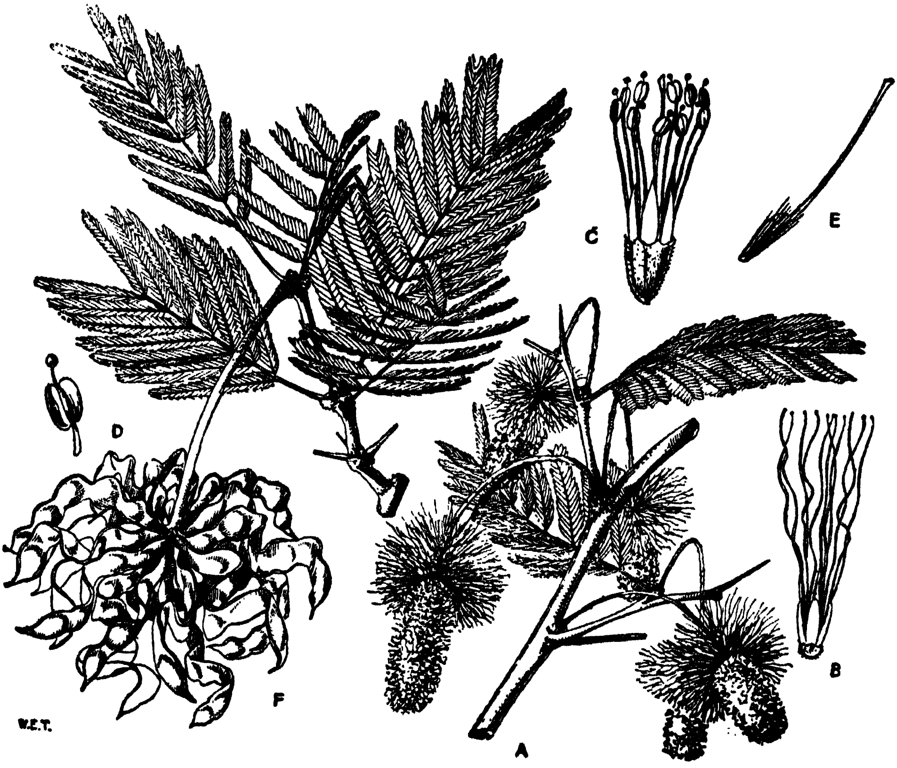


FIGURE 15.—**Dichrostachys glomerata** Chiov. **A widespread tree in the drier parts** of tropical Africa, the gum of which is sometimes collected (A, branch, showing inflorescence; B, neuter flower from base of inflorescence; C, bisexual flower from upper part of inflorescence; D, anther; E, pistil; F, fruiting branch; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Cussonia:—In Northern Nigeria *C. nigerica* yields a clear colourless gum when wounded, which hangs in slender pencils and is believed to have some slightly irritant quality (DALZIEL).

Cycas:—Gum is produced by *C. circinalis* and *C. rumphii* in the eastern tropics and appears to be largely of an insoluble nature. Specimens of gum of *C. circinalis* in the Kew Museum are in large dark brown lumps.

Dichrostachys:—*Dichrostachys glomerata* (syn. *D. nutans*) is a very common and characteristic plant throughout the drier areas of tropical Africa. In East Africa, where it often takes possession of abandoned native farms gum may be obtained from it (GREENWAY). This shrub or small tree with its handsome pinkish yellow flower-heads and clusters of twisted pods has many uses among the natives. It is often a valued source of fuel but may be troublesome as a weed in cultivated land and by roadsides.

Echinocarpus:—The gum of *E. australis* has been used in Australia in stiffening straw hats (MAIDEN 1901).

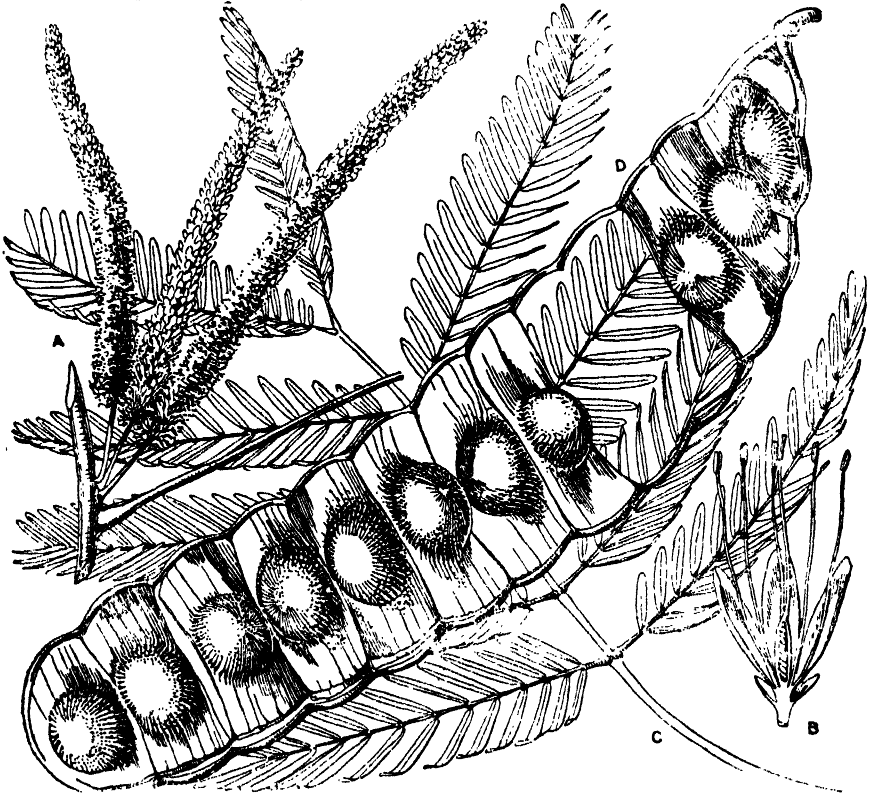


FIGURE 16.—**Entada sudanica** Schweinf. A common tree throughout tropical Africa. Generally yields a poor quality gum (A, inflorescence; B, longitudinal section of flower; C, leaf; D, fruit; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Elæocarpus:—MAIDEN (1901) refers to small quantities of pale coloured gum exuding from the following Australian species:—*E. reticulatus, E. obovatus,* and *E. grandis.*

Encephalartos:—Some species are gum yielders (VON WIESNER). A specimen of gum from *E. hildebrandtii* in the Kew Museum collected by Sir JOHN KIRK in Zanzibar consists of clear yellow or pale brown pencils and tears.

Entada:—*Entada sudanica,* a widespread tree throughout West Africa, often yields gum which does not however appear to be of very high quality (Bull. Imp. Inst. **32**:353) but may vary from different regions. This small tree is very prevalent in savannah areas from the Gambia to northern Nigeria. It also extends to the Red Sea provinces and south to the Zambesi. The leaves are often used as fodder.

Erythrophloeum:—*E. africanum* yields an amber coloured gum in East and West Africa.

Flindersia:—Several species yield gum of fairly good quality in Australia. *F. maculosa* ("spotted" or "leopard tree") may produce it in abundance and this has been described as one of the best Australian gums (MAIDEN 1901). *F. australis,* ("cudgerie" or "crow's ash"), plentiful in northern New South Wales and Queensland, yields a similar gum and that of *F. bennettiana* ("Bennet ash") is also mainly water soluble. These gums have good adhesive properties.

Garuga:—*G. pinnata,* a large deciduous tree widespread in India, produces a clear gum or gum-resin very freely which is greenish yellow in colour but regarded as of no particular value (GAMBLE).

Geijera.—*G. muelleri* ("ironwood" or "axebreaker"), a Rutaceous tree 40-60 feet high, of New South Wales and Queensland, is a gum yielder. Gum from Lismore, N.S.W., was described as being in large tears, light amber to lightish brown, transparent with a very bright fracture. Although somewhat tough, the gum powdered fairly well. It was only partly soluble in water (MAIDEN and SMITH).

Geodorum.—The tuberous roots of a Philippine orchid, *G. nutans,* are said to contain a gummy substance used as glue for cementing together parts of mandolins, guitars and other musical instruments. In preparing the "glue" the rhizomes are first boiled (WEST and BROWN 1920).

Hakea:—Gums somewhat resembling those of *Sterculia* have been obtained from certain species of this large Australian genus (*e.g. H. acicularis* and *H. macraeana*) (MAIDEN 1901).

Khaya:—Some of the African mahoganies are known to yield gum. *K. senegalensis* sometimes produces it very freely. A sample from Nigeria examined at the Imperial Institute was found to consist of conglomerates, vermiform fragments and dust, which were semi-transparent and very pale greenish yellow to golden yellow in colour. The gum was semi-soluble in water swelling to a mucilaginous mass. It was considered the lighter coloured pieces might be saleable in London but not the dark coloured. The gum would need to be collected only in the dry season. (Bull. Imp. Inst. **32**:355). Gum is also produced by *Khaya grandifoliola* in West Africa and by *K. madagascariensis* in Madagascar (DE CORDEMOY).

Lagerstroemia:—*L. parviflora,* a large forest tree that occurs almost throughout India, yields a gum reputed to be sweet and edible. Light and dark coloured tears are in the Kew collection.

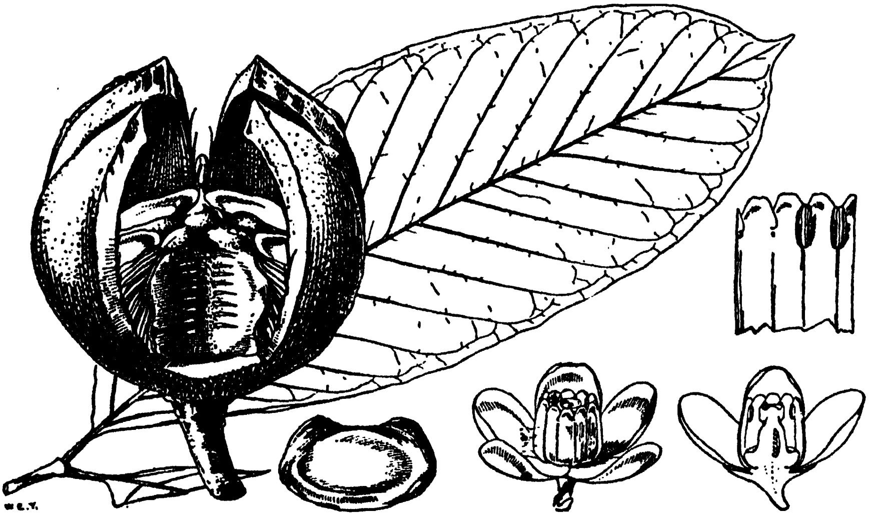


FIGURE 17.—**Khaya grandifoliola** C. DC. (African mahogany). Gum from the African mahoganies is usually dark coloured and of poor quality (A, leaflet; B, flower; C, same in vertical section; D, staminal tube from inside; E, cross section of ovary; F, fruit with portion of wall removed; G, winged seed; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Lannea:—This is yet another Anacardiaceous genus of the Old World tropics that contains species known to yield gum freely at times. Among these are *L. acida, L. barteri* and *L. fruticosa,* all native to West Africa. *L. fruticosa* also occurs in the Sudan, Abyssinia and Uganda. The gum of *L. acida* is eaten by natives (DALZIEL).

Macrozamia:—Gum has been recorded from several Australian species. (DE CORDEMOY). That of *M. spiralis* ("burrawong") in the Kew Museum is clear, dark brown and in large and small tears. It is not completely soluble.

Melia:—*M. azedarach,* a tree reaching 40 feet or more in height and believed to be native of S. W. Asia but now widely cultivated and naturalized in warm countries, sometimes yields gum freely. Among the numerous common names applied to the tree are:— "Persian lilac," "syringa," "pride-of-India," "China tree," etc. The gum is tasteless, clear, pale or dark amber in colour and of good solubility.

Melicope:—The gum of *M. neurococca,* a small tree found from the Hastings River, N.S.W., to Maryborough, Queensland, may occur in large tears or globular masses. It is said to resemble closely that of *Geijera* *muelleri,* also Australian, and belonging to the same family (*Rutaceae*). (MAIDEN and SMITH).

Moringa:—The horseradish tree, *M. oleifera,* (synonym *M. pterygosperma*) cultivated throughout the tropics for its edible pods and seeds, and wild in northern India, sometimes produces gum freely, especially as a result of insect attack. The gum is at first white but darkens on exposure to the air, becoming reddish brown or brownish black. It is a gum of the tragacanth type, showing cellular structure and swelling to a jelly with water. The gum is used medicinally by natives in India and Java (intestinal complaints), and is said to have been employed in calico printing in India (HEYNE). A detailed account of it is given by VON WIESNER.

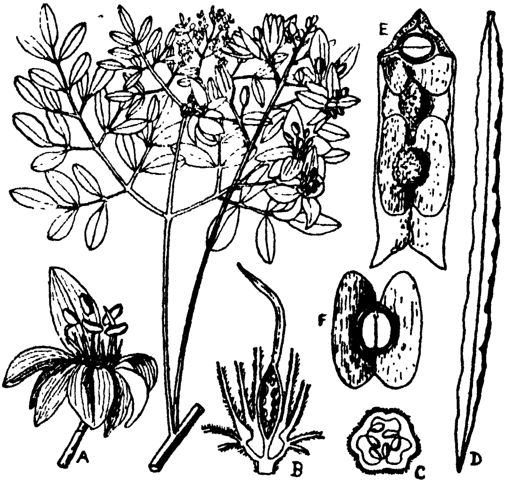


FIGURE 18.—**Moringa oleifera** Lam. (horseradish tree). Cultivated throughout the tropics. Sometimes yields gum freely as a result of insect attack (A, flower; B, longitudinal section of flower; C, cross section of ovary; D, fruit; E; portion of fruit opened; F, seed; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Owenia:—In Australia members of this endemic genus yield gum, notably *O. cepiodora* "onion wood" of New South Wales and *O. venosa* common in the dry scrub forests of coastal Queensland.

Panax (Tieghemopanax):—MAIDEN has described the gums of *P. sambucifolius* var. *angusta, P. elegans* and *P. murrayi* in Australia. In general they resemble gum arabic in appearance, but are not wholly soluble and may be scented. *P. colensoi* in New Zealand also yields gum.

Penæa:—"Gum sarcocolla" that was so much esteemed for medicinal use in the past is believed to have been partly derived from this genus and from *Astragalus* in the case of the Persian sarcocolla.

Pentaceras:—The gum of *P. australis* ("scrub hickory") is said to be similar in colour, appearance and physical characteristics to that of

Melicope neurococca also one of the Australian *Rutaceae* (MAIDEN and SMITH).

Prunus:—Cherry gum (*P. cerasus*) has been collected and used in Europe for technical purposes for many centuries but latterly it has been superceded by gum arabic or acacia gum. The gums of other temperate stone fruits, such as the almond (*P. amygdalus*), plum (*P. domestica*) apricot (*P. armeniaca*) and peach (*P. persica*), being similar, have also been used and have in fact appeared in trade under the name of "cherry gum." Sometimes these gums are produced in large quantity as a result of a pathological condition of the trees ("gummosis"). Cherry gum is usually darker in colour than gum arabic and is only partly soluble in water, the remainder swelling to a jelly. It is more difficult to pulverize and is inferior in adhesive properties to gum arabic. The gum has in the past been treated chemically to improve colour and solubility.

Gums of this class which somewhat resemble gum tragacanth in jellying properties, but which are darker than tragacanth have been termed "Bassora gum" in the trade. In the latter part of last century a gum known as Persian or Persian insoluble gum frequently appeared in commerce. This gum was believed to be derived from species of *Prunus*. That *P. leiocarpa* was one of the sources is indicated by the following remarks of Dr. OTTO STAPF who collected the gum in 1885. "I may add that I saw a kind of cerasin (gummi nostras) being sold in the bazaars at Shiraz for medicinal purposes. It was called "Ketirah-i-Arjen" and stated to be derived from the Arjen shrub (*Amygdalus leiocarpa*). Later I myself collected it from this species on Kuk Chah Sia, north of Shiraz, where it was plentiful on the ground underneath a few shrubs and also on the stems." (Kew Bull. 1906:110).

Gum from Baluchistan derived from *Prunus eburnea* has been favourably reported on in the past. This gum is of the soluble class and considered to be suitable for pharmaceutical and confectionery purposes. (Imp. Inst. Rpt., Gums and Resins, 1909). *P. eburnea* is a small tree or large shrub with silvery white branches and pink flowers. It is common and often gregarious in the Juniper tracts of Baluchistan.

Pseudocedrela:—*P. kotschyi,* a large timber tree of the dry forests of West Africa, commonly produces gum, usually dark in colour. A Gold Coast sample examined at the Imperial Institute consisted of pale yellow to yellowish brown tears. It has good solubility, giving an almost tasteless, yellowish brown, although turbid mucilage. (Imp. Inst. Rpt., Gums and Resins, 1909). A later sample (1934) from Nigeria was considered at the time to be of no commercial value.

Saccopetalum:—In India, *S. tomentosum,* a large deciduous tree found in Oudh and southwards throughout the Peninsula, produces a gum ("karee" gum) which belongs to the tragacanth or "hog gum" class. A specimen in the Kew Museum is pale yellow and looks not unlike tragacanth.

Sarcostemma:—A clear pale yellow gum from *S. brevistigma* from the Deccan, India, is in the Kew collection. This Asclepiad is a leafless, jointed, fleshy climbing shrub. The gum has no recognized uses as far as is known.

Schefflera:—In East Africa *S. volkensii,* which is locally common in mountain evergreen forest, yields a gum used by some tribes for colds, coughs and lung troubles. (GREENWAY).

Sclerocarya:—*S. birrea* is a common Anacardiaceous tree in many of the drier areas throughout tropical Africa and is characterized by a mango-like fruit. A clear light coloured gum may exude from the bark. This becomes brittle and friable when dry and is used in West Africa, mixed with soot and water, to make ink. The juice of the fruit may be fermented to make a beverage like cider or boiled down to a thick black syrup and used for sweetening. The leafy branches may be cut for fodder (DALZIEL). In East Africa the tree is grown from cuttings and planted round villages.

Semecarpus:—In India *S. anacardium,* the "marking nut tree" yields a dark or blackish insipid gum or gum-resin. It is not known to be used for any special purpose.

Sloanea:—*S. woollsii* ("carrabeen"), a large buttressed tree of New South Wales and Queensland, yields gum (MAIDEN 1901).

Soymida:—*S. febrifuga,* a large timber tree of the dry forests of central and south India, yields a beautiful clear gum in large pieces which is said to afford a good adhesive mucilage (GAMBLE). In the Kew collection, specimens of this gum range from pale yellow to dark brown.

Tamarindus:—The tamarind, *T. indica,* so common and well known in the African and Asiatic tropics, yields a dark coloured gum of poor solubility which swells considerably in water but is regarded as of no special value.

Tarrietia:—The gum of *T. argyrodendron* ("silky elm" or "ironwood") in New South Wales and Queensland and of other species of *Tarrietia* in Australia is said to be similar to *Sterculia* gum. (MAIDEN 1901).

Terminalia:—Several species in this large genus are known to yield gums. These appear to be of varying quality and solubility. The species include:— *T. catappa, T. belerica, T. tomentosa* in India, *T. macroptera, T. stuhlmannii* and *T. superba* in Tropical Africa, as well as Australian species. Large attractive amber coloured tears of *T. tomentosa* are in the Kew collection. This gum is eaten by natives in India. The tree is one of the most widely distributed of the important Indian forest trees. The tasar silkworm (*Antheroea paphia*) feeds on its leaves. The gum of Australian species is also eaten by aborigines but there are indications that it may have a purgative effect on those unaccustomed to it (MAIDEN

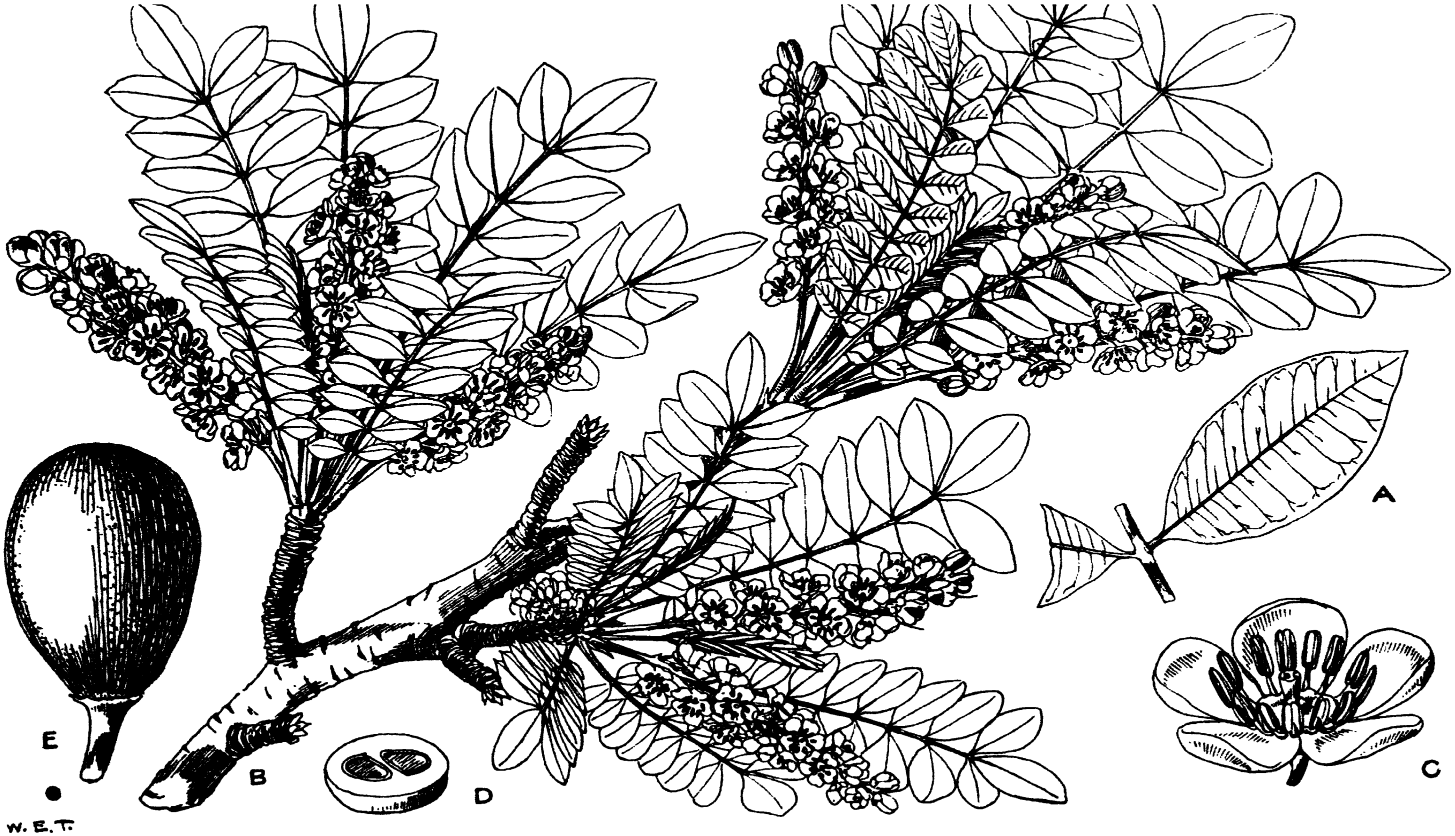


FIGURE 19.—**Sclerocarya birrea** Hochst. The gum may be used by natives in West Africa to make ink (A, leaflet showing venation; B, habit; C, flower; D, cross section of ovary; E, fruit; *from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

1901). The gum or gum resin known as "Ashanti gum" on the Gold Coast is believed to be largely the product of *T. superba* (Dalziel).

Thevetia:—*T. neriifolia,* cultivated throughout the tropics as an ornamental shrub or street tree, yields a dark coloured gum which is tasteless and mainly insoluble, swelling in water.

Virgilia:—*V. capensis,* an ornamental South African tree with lilac flowers and which is sometimes cultivated, yields gum, which may appear as fairly large vitreous tears. According to the label on a specimen in the Kew collection the gum "exudes very freely from the bark and is used as a substitute for starch by the bush women."

Part II

RESINS

Chapter VII

PROPERTIES AND USES OF RESINS

The term resin is not easy to define in a precise manner, for those substances that are commonly termed resins differ a good deal among themselves both in physical properties and in chemical composition. However, they do possess certain properties in common and form a distinct group of plant products easily recognizable in practice. They are insoluble in water but usually dissolve readily in alcohol, ether, carbon bisulphide and certain other solvents. With heat they first soften and then melt to a more or less clear, sticky fluid. They burn with a smoky flame and are resistant to most reagents and to decay.

The Origin of Resin in the Plant:—All the natural resins are of vegetable origin with the exception of lac, and similar insect exudations which are never present in sufficient abundance to make collection worth while. Plant resins are widely distributed in the vegetable kingdom and may be present in almost any organ or tissue of the plant. Sometimes they are excreted on the surface of the plant in a more or less natural fashion or they may occur only in the inner tissue and not be visible. As with gums, a distinction has been made by some authorities between "physiological" and "pathological" resins, but in many instances there is doubt as to which of these two groups certain resins should belong. Although resins are so widely distributed in the plant kingdom they are usually produced in small quantities only, and economic importance is attached to only comparatively few of them. Usually resin is not produced freely unless there has been injury of some sort such as that caused by other falling trees or branches in the forest, or that due to animal or insect agency, the last mentioned being of very common occurrence. For this reason, tapping of some form or other has usually to be resorted to in order to obtain a free production of resin from the plant.

Resin is generally secreted in plant tissue in special cavities or resin ducts and rarely, if ever, in the actual living cell. These cavities are lined with a special layer of secretory cells ("resinogenous" layer) which secretes the resin into the cavity through a thin cuticular skin. The cavities themselves may form in either a schizogenous or lysigenous manner, usually the former, and are often elongated in shape or in the form of canals. Frequently they are much branched or of an anastomosing nature with the result that when one of these passages is severed, as in wounding or tapping, the resin flows to the wound from a considerable distance. Resins are frequently present in latex vessels. This is noticeably the case in many of the *Euphorbiaceae* and is of some economic significance in that the presence of resin in any quantity in the rubber derived from such latex considerably reduces its commercial value.

The method of formation of resins in the plant is little understood, but it is believed by some that they form through polymerization and reduction of carbohydrates, particularly starch. They do not appear to enter into the active metabolism of the plant in any way, and in some instances may exist as secondary products, as from the oxidation of essential oils. With regard to the function of resins in the plant, it is generally held that while they may not be of any use in the growth of the plant or the actual repair of injury they may assist in preventing the desiccation of the injured tissue and in preventing further injury through decay.

The Main Resin Producing Families:—The families notable for resin production occur more or less scattered over the whole range of flowering plants, *Dicotyledons* and *Monocotyledons* alike, and of course the *Coniferae*. They do not belong to any particular group or cohort of families, but seem in the main to be absent from those families that are classed as the higher *Polypetalae* and which include such families as the *Labiatae, Scrophulariaceae, Verbenaceae,* etc.

The three most important families for the bulk production of natural resins for commercial purposes are the *Pinaceae, Leguminosae,* and *Dipterocarpaceae.* The first mentioned includes the pines yielding colophony (rosin and turpentine). The *Leguminosae* include the copals from various parts of the world belonging to such genera as *Copaifera, Trachylobium, Hymenaea, Daniellia,* etc. The *Dipterocarpaceae* include the dammars from tropical Asia and the Pacific region derived from species of *Hopea, Shorea, Balanocarpus, Pentacme* and other genera. The family *Burseriaceae* is notable as a resin or balsam yielding family and the source of soft resins of the elemi type (*Canarium* and *Protium* spp.), and of aromatic resins such as frankincense (*Boswellia* spp.) and myrrh (*Commiphora* spp.). Another family well known for scented and medicinal resins is the *Umbelliferae* with such products as asa-foetida, galbanum (*Ferula* spp.), ammoniacum (*Dorema* spp.) and opoponax.

The following are the main resin yielding families with the resins they yield:—

Gymnosperms	
Pinaceae	Colophony: Canada balsam: Sandarac: Kauri resin: Manila copal.
Dicotyledons	
Berberidaceae	Podophyllum
Guttiferae	Gamboge
Dipterocarpaceae	Dammars (various)
Zygophyllaceae	Guaiacum
Burseraceae	Elemi, Frankincense, Myrrh
Anacardiaceae	Mastic
Leguminosae	
a. *Caesalpinaceae*	Copals (various)
b. *Papilionaceae*	Tolu and Peru balsam
Hamamelidaceae	Storax
Umbelliferae	Asa foetida, Galbanum, Ammoniacum, etc.
Styracaceae	Benzoin
Convolvulaceae	Jalap, Scammony
Monocotyledons	
Liliaceae	Acaroid resin, Dragon's Blood, Aloes

There has been much confusion in the past regarding the botanical origin of many of the resins that have entered commerce. The reasons for this are not difficult to find. With those resins recovered from the earth, such as many of the better class copals, the reasons for doubt as to botanical origin are obvious. With resins obtained from living trees the trees in question are often tall forest trees and the obtaining of adequate herbarium specimens (leaves, flowers and fruits) for botanical identification, no easy matter. This may be further complicated, especially with the Dipterocarps, to which the large group of Malayan and East Indian dammars belong, by the fact that many trees do not flower and fruit every year but only sporadically and then for only a very short period. However, thanks to the coöperation of forest and other field officers, in many countries, a good deal of headway has been made in ascertaining the correct botanical identity of many of the less known resins.

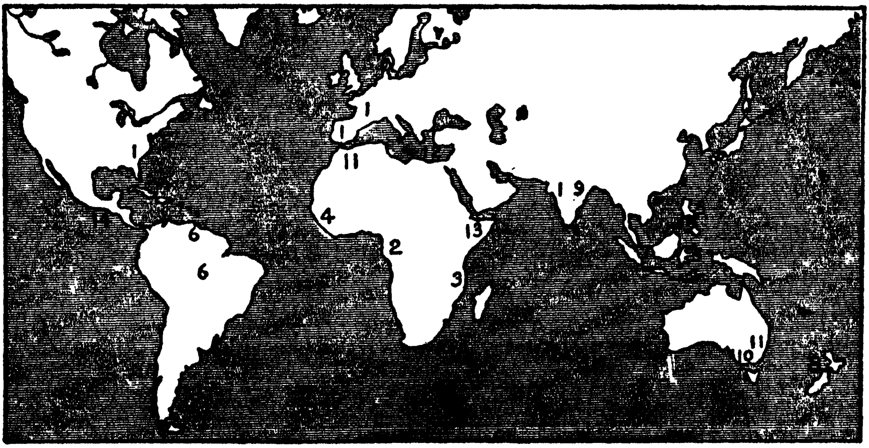


FIGURE 20.—MAP SHOWING THE DISTRIBUTION OF THE MORE IMPORTANT VEGETABLE RESINS: 1, Rosin or Colophony (*Pinus* spp.); 2, Congo Copal (*Copaifera demeusei* Harms); 3, East African Copal (*Trachylobium verrucosum* (Gaert.) Oliv.); 4, West African Copal (*Copaifera* spp.); 5, East Indian Copal (*Agathis alba* (Lam.) Foxw.); 6, South American Copal (*Hymenaea* spp.); 7, Dammar (*Dipterocarpaceae*): 8, Kauri Resin (*Agathis australis* Salisb.); 9, Lac; 10, Accroides (*Xanthorrhoea* spp.); 11, Sandarac (*Tetraclinis articulata* Mast.: *Callitris* spp.); 12, Mastic (*Pistacia lentiscus* L.); 13, Frankincense (*Boswellia* spp.); 14, Peru Balsam (*Myroxylon pereirae* Klotzsch).

The Physical Properties of Resins:—The natural resins as a group are so heterogeneous that very few generalizations are possible with regard to their physical properties. The fact that all are insoluble and unaffected by water serves to distinguish them from the gums. They are on the other hand, soluble to a greater or less extent in various organic solvents that have no effect on gums. As resins vary so much among themselves in their physical properties and their solubility it has been thought fitting to refer to these properties in those chapters which deal with the individual resins or the plants yielding them.

Hardness is one of the most noticeable as well as one of the important properties of resins. Usually the hardest resins give the hardest and most durable films in varnish making. The nature of the varnish film is also dependent upon the solvent and other ingredients used in the varnish, and the skill with which it is made. In the natural state resins may be extremely hard and brittle, such as amber and some of the copals. On the other hand, they may be so soft as to be easily kneaded with the fingers, such as the elemis and certain of the medicinal resins. Some may be even semi-fluid, as are the pine resins or oleo-resins and Burgundy pitch. Intermediate stages of hardness exist among the other resins. In practice it is found that hardness may vary with one and the same resin to quite an appreciable extent. This is known to apply, particularly to Kauri resin from New Zealand and to Manila copal. Attempts to draw up scales or tables of hardness for plant resins for diagnostic purposes, which have been made in the past, have not met with much success.

The colour of resins is most variable and may range from colourless or water white through various shades of amber and brown to pink. Sometimes a pink or reddish tinge may be present; frequently to be seen in Congo copal. Most resins are transparent and break with a clean vitreous fracture but some are opaque. Like gums they may weather or become fissured with long exposure to the atmosphere. They may occur as small tears only on the trunk but often the resin is present in large masses. With fossil resins like kauri and East Indian copal the pieces may be of considerable size and weight.

The natural resins do not usually have a definite melting point, which is not surprising in view of the fact that they are in the main complex mixtures rather than pure substances. On heating, fusion takes place gradually and with the harder resins a certain amount of decomposition takes place. With the soft resins, such as some of the dammars and rosin, melting commences at about 100° C., the transition stage extending over about 10°. The melting points with the hard resins is considerably higher (300-350° C.) and the transition stage longer (T. HEDLEY BARRY 1932). Hard resins require heat treatment before admixture with oil, such as linseed oil, in vanish making.

The specific gravity of resins does not show a wide range of variation and usually lies between 1.06 and 1.08. This is lower than that of many of the common synthetic resins. The presence of small air bubbles, not always easily detected, may make accurate determinations difficult. In the examination of resins the use of ultra violet light, X-ray spectra and capillary analysis have been made use of by various workers (HEDLEY BARRY 1932; WOLFF 1928).

Chemical Composition:—Most resins, particularly those of value in varnish manufacture, consist essentially of acids and neutral bodies termed resenes. The resenes are inert bodies notable for their resistance to chemical reagents and appear to be of an aromatic nature, but cannot be placed in any definite chemical category. With varnish resins, however, the inertness of the resenes does not seem to have any direct bearing on the hardness or durability of the varnish film as might be expected. Nevertheless, the resenes are believed to play an important part in relation to the properties of a resin. In some instances their oxygen content is so low that they might be hydrocarbons of high molecular weight. Little is at present known regarding their nature and function, especially in regard to their relations with the acidic substances in resins. It is thought they may have an important bearing on the solubility of a resin and may act to some extent at least as a protective colloid (HEDLEY BARRY).

Other important constituents of resins in addition to resenes are aromatic acids, aliphatic acids, resinols and resino-tannols (alcoholic constituents), resin acids (acidic constituents) and essential oils. With regard to the first of these, acids of the benzoic and cinnamic acid series are to be found in some resins *e.g.* benzoic acid in "gum benzoin", acroides, Peru and Tolu balsam: cinnamic acid in storax and benzoin, and succinic acid is found in amber. TSCHIRH, who has probably worked more intensively than anyone on the chemistry of resins, divides the alcoholic constituents into two groups—the resino-tannols which give the tannin reaction and the resinols which fail to do so. Resino-tannols are related to the tannins and give similar degradation products. It is thought that in some instances these form only on exposure of the resin to air and are not present when the resin first forms.

The acidic constituents of resins occur either free or combined. Only in a few instances has their constitution been closely studied, *e.g.* abietic acid and its allies derived from rosin or colophony, and to a less extent the resin acids of Manila copal, kauri, sandarac and accroides.

Essential oil is sometimes an important constituent of a resin. The fossil resins contain practically no essential oil and the hard resins very little. Many resins contain small amounts of essential oil while others have a high percentage, such as the oleo-resins and balsams or medicinal resins. In the elemis there is sufficient essential oil present to give them a soft consistency and to enable them to be kneaded with the fingers. The balsams are regarded as solutions of resins in essential oils.

The free acidity of resins is of some importance, for resins with a high figure may have a deleterious effect on varnishes, especially if they are used in conjunction with basic pigments. The heat treatment necessary for hard resins before admixture with oil generally lowers the free acidity sufficiently for this to be of no account. Acid value may also be of consequence in detecting adulteration in some instances. For detailed accounts of the chemistry of resins the reader is referred to the works of TSCHIRCH, WOLFF and HEDLEY BARRY.

Main Uses: Competition from Synthetic Resins:—The use of natural resins by man for varnished or protective coatings and as medicines or sources of perfume go back to very early times. The ancient Egyptians are known to have used a resin of some sort on their mummy cases. This is believed to have been a pine resin or oleo-resin smeared on the mummy case rather than any form of spirit varnish, for the distillation of alcohol was unknown to the Egyptians. The Incas of South America used embalming resins believed to consist in part at least of Peru and Tolu balsam. Copal (*Hymenaea?*) formed part of the tribute paid to the monarch of the Aztec Empire by the different states and the word "copal" is believed to be of Mexican origin. The use of resins for torches and for caulking boats and canoes by primitive peoples is well known. Lac has long been used in India.

Fragrant resins such as frankincense and myrrh were used in biblical times and before the Christian era when they were important articles of trade in eastern Mediterranean countries and Asia Minor. Apart from their use in incense, they were employed in making perfumes and unguents. Frankincense was one of the most important objects of the traffic which the Phoenicians and Egyptians carried on with Arabia. Among the medicinal resins or oleo-resins that were well known to the Ancients, or which entered into European commerce in the middle ages through the trading cities of Italy, were asafoetida, galbanum and ammoniacum. Such resins are now but little used in medicine.

The present day uses of resins are numerous and they are employed by a large number of different manufacturing industries. The most important use, particularly for the hard resins like the copals and some of the dammars, is in the manufacture of varnishes, paints and lacquers of various kinds. Large quantities, particularly of rosin, are employed in the paper industry for paper sizing—to impart lustre and weight and to hinder the absorption of ink or moisture. In combination with alkalis rosin is also used in soap making. Other minor uses of rosin are in the making of rosin oils for special lubricating purposes. Resins are an important constituent in the manufacture of linoleum for which large quantities have been used. Sealing wax is one of the minor uses for which resins, particularly shellac, are employed.

Turpentine is in effect a resin product and indispensable in connection with paints and varnishes. It is also much used in polishes of various kinds and as a basis for the manufacture of synthetic camphor.

The varnishes made from natural resins fall into two main categories—oil and spirit varnishes. Among the spirit varnish resins, shellac is the most important and the most extensively used. Other spirit varnish resins are sandarac, mastic and certain dammars, mainly used for special purposes. Sandarac yields a hard white spirit varnish useful for labels, cardboard, leather goods and for metals. Mastic is mainly employed for pale, high grade varnishes for the protection of oil and water colour paintings. The manufacture of varnish from natural resins is of a highly technical nature requiring much experience and skill. Readers are referred to the works of CHATFIELD (1944), MORRELL (1923), GAULD BEARN (1923) and others.

The bulk of the natural resins used in varnish making (oil varnishes) belong to one or the other of the large group of copal resins, particularly Congo copal, which has been exported in very large quantities to manufacturing countries in all parts of the world in the last two or three decades. In recent years, however, there has been a marked falling off in its use for varnish on account of the competition from synthetic resins. The uniformity of the synthetic resin as compared with the natural product is of very great value to the manufacturer. To what extent natural resins may continue to be supplanted by the synthetic product probably no one is able to forecast with any accuracy. The development of cellulose varnishes and lacquers, now so extensively used for the surfacing of automobiles, for furniture and for house decoration, has resulted in a considerably decreased use of natural resins for such purposes. Their cleanliness, uniformity, applicability to spraying processes, quick drying and durability on metal and under outdoor conditions are some of the qualities that have led to their extensive use. However, many hold the view that the cheap production of natural resins accompanied by more careful grading and sorting, resulting in a more uniform commodity for the user, may enable the natural product to hold its own in many fields. A combination of the natural resin with the synthetic has in fact proved a happy combination for many purposes.

Good examples of the combined use of natural and synthetic resins are to be seen in the new class of resins known as "copal type synthetics." In these, natural copal is blended with synthetic resin, usually of the phenolic or maleic type, or combinations of these. The product shows many of the good qualities of both the parent resins. In spite of the more obvious drawbacks of natural resins when compared with their synthetic counterparts, certain valuable properties are often more pronounced in the natural resin. In this connection KRUMBHAAR (1947) states—"The old time varnish makers used to cite a number of advantages of copal varnishes over varnishes based on synthetics. According to them all copal ester varnishes have higher viscosity, better bodying and drying properties, greater toughness and durability of the dried film, than rosin ester varnishes, all other conditions being equal. Compared to modified phenolics, copals are reputed to produce glossier varnishes with less tendency to blooming. Copals are also considered to cause better adhesion of varnishes, especially when the latter are baked on metal; and they have the well established reputation of producing varnishes which, when used as interior can coating, do not give off any unpleasant odor or bitter taste to aqueous liquids, such as beer or fruit juices, with which they come into contact. When copal varnishes are compared to maleic resin varnishes, it is admitted that their dried films are dark in the beginning, but it must be emphasized that they soon bleach out; and it is stressed that copal varnishes, under otherwise equal conditions, are superior in rubbing and wearing characteristics.

The rivalry between natural gums and synthetic resins has given great impetus to research workers in both fields, with the result that knowledge gained on constitution and production of synthetic resins proved helpful in the chemistry and processing of copal gums, and vice versa. The natural opposition of the two classes, however, persisted until research developed a group of resins, which combine the advantages of both natural and synthetic resins, and eliminate many of their respective weaknesses. This new resin class, which is distinctly different from modified phenolics and maleics, is well characterized as the group of copal-type synthetics, because it combines the features of both natural and synthetic resins, emphasizing particularly the desirable features of the fossil gums. The most important copal-like property, as compared to the properties of orthodox synthetic resins of the same melting point and viscosity, is the high degree of solubility, molecular homogeneity, mechanical toughness and heat stability."

According to KRUMBHAAR (1947) this new group of resins—the copal type synthetic resins—possess unusual property combinations which result from the unique process of gelling and degelling used in their preparation.

Their good solubility in many types of aliphatic hydrocarbons and in oils at low temperatures are among their advantages. They are the quickest drying resins available and their varnishes are distinguished by pigment stability, non-skinning properties and the absence of after-bodying. Their water resistance is close to that of varnishes made with high grade modified phenolics. Their uses include—"agricultural implement finishes, alkyd resin modifications, architectural finishes, blending varnishes, brewery finishes, can stable paints, closure finishes, cold cut solutions, drum coatings, four-hour enamels, fuel wagon finishes, hardware finishes, highway marking paints, house paints, industrial finishes, laundry equipment finishes, metal furniture finishes, operating room enamels, passenger car inside paints, radiator finishes, refrigerator enamels, safety equipment finishes, shelf goods, ship inside paints, soft oil varnishes, textile machinery paints, traffic paints, varnish stains."

Chapter VIII

THE COPALS

The term copal is used in European and American markets and in the resin trade generally for a large group of resins characterized by their hardness and their relatively high melting point. Some are among the best of the natural resins for use in varnish and paint manufacture. They are derived from a number of different plants, mainly forest trees of the family *Leguminosae* that occur in various parts of the world. Some of the resins occur in the fossilized or semi-fossilized condition and have to be recovered from the earth. A number, in fact most of the copals that were freely exported previously, are no longer exploited. At one time copals were employed more or less exclusively for varnish manufacture, the soft copals—nearly completely soluble in cold alcohol, being used for spirit varnishes without further preparation, and the hard or half-hard copals being subject to heat treatment (or "running") to render them soluble in drying oils. More recently, the harder copals, on account of their thermoplastic character, have been used for all manner of pressed and stamped articles in the form of a binder, often in combination with shellac.

Congo Copal:—During the last two or three decades, the copal derived from the Belgian Congo has been by far and away the most important copal in the world's markets, the quantity produced greatly exceeding that from any other region. With a production of some 21 thousand kilos in 1908 this had risen to 13 million kilos in 1920 and not far short of 18 million kilos in 1935, valued at over 26 million gold francs. Since that time, exports have fluctuated, but nevertheless, the industry is still a valuable one.

In areas where the resin is found, native collectors locate the pieces by prodding the ground with iron tipped sticks. They are mainly located at depths from 6 inches to 3 feet. A good collector may obtain 25-30 kilos of resin a day, but the average is 15-18 kilos. The main collecting time is May to July. The resin is also found in riverbeds in the dry season or on the sandy river beaches. The marshy forests bordering the rivers in the following districts are where most of the resin is obtained—Lake Leopold II, Bangala, Egnateur, Ubangi, Moyen Congo, Kasai, Stanleyville and Aruwimi. The total area of the Belgian Congo is about equal to that of France and it has been estimated that potential supplies of the resin may be almost inexhaustible.

After collection, the pieces of resin are roughly cleaned and taken to a collecting centre. At one time more thorough cleaning and grading was effected before shipment, the resin being immersed in a 1% caustic soda solution and exposed to the air to become clearer and harder. Cleaning is now done more efficiently in Europe by special mechanical means involving the use of an air blast with iron filings. Magnetic means are used to separate the iron filings from the resin dust. Grading of the cleaned copal is carried out by hand and is for colour and size. The four main or basic grades are clear white, pale yellow, amber and brown or opaque. Among the different classes of resin that appear on the resin market at Anvers are—*blanc cristal, jaune transparent, blanc laiteux, brun clair, brun plus foncě, jaune opaque* and *crouteux jaune* (DE WILDEMAN 1933).

The Congo resin is considered to be derived mainly, if not entirely, from *Copaifera demeusei,* still a common forest tree of the region. There are many other resin yielding trees in the forest. These include other species of *Copaifera* and trees belonging to such genera as *Pterygopodium, Gossweilerodendron, Pterocarpus, Amphimas, Dialium* and *Tessmannia,* but their contribution to the commercial supplies of the resin is considered to be negligible. *Copaifera demeusei* also occurs in Southern Nigeria and Cameroons.

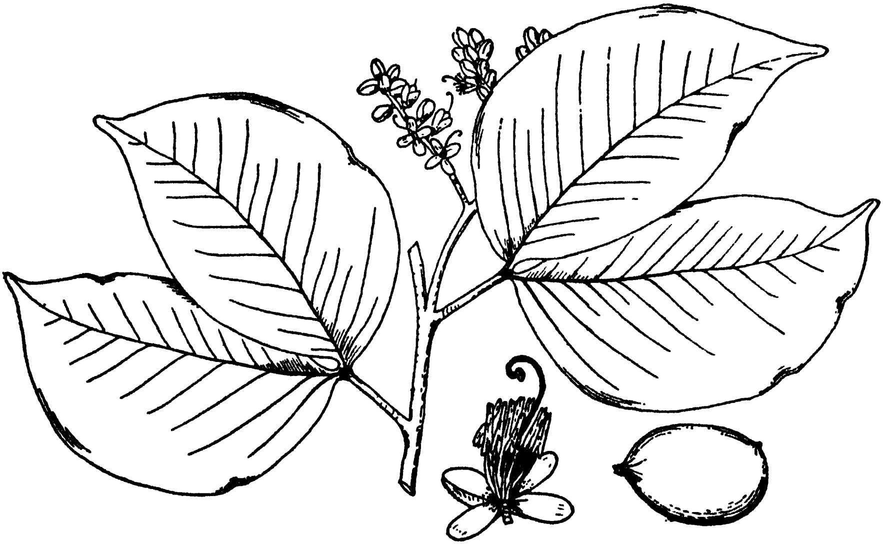


FIGURE 21.—**Copaifera demeusei** Harms. The source of Congo copal, the most important commercial copal.

The tree is mainly to be found in the central basin of the Congo and may reach a height of 50-60 m. It has a characteristic, smooth, light coloured bark. The heartwood is hard and dark in colour. Flowering generally takes place in April, the flowers being relatively small and inconspicuous. These are followed by the flat oval pods, with a wrinkled surface and up to 4 cm. long and 2-3 cm. wide. The leaflets are in pairs on a common petiole 2-4 cm. long. They are smooth and shiny and commonly 9-12 cm. long and 4-6 cm. wide.

In addition to the fossilized or semifossilized resin, fresh resin is sometimes collected from the living tree, but there does not appear to be systematic tapping. It has been shown that trees of *Copaifera demeusei* in different parts of the Congo vary much in the facility with which resin is produced on wounding.

The physical and chemical properties of Congo resin vary to a greater extent than might be expected. Variation in colour and hardness in commercial samples is very obvious. Colour ranges from water-white to brown. The analysis of 13 specimens differing in appearance showed acid values ranging from 42 to 150.5 and iodine values from 54.5 to 110.5 (HEDLEY BARRY).

West African Copals:—Various West African copals have appeared in European and American markets in the past but these have been superseded by Congo copal for the most part, and are not regularly exploited at the present time. These copals were usually known in the trade by their country or place of origin, *e. g.* Sierra Leone, Conakry, Benin, Accra, Angola, Benguela, etc.

A good quality fossil copal in the form of small rounded pieces was at one time exported from Sierra Leone. Prices on the London market in the year preceding the second world war varied from 9d. to 1s.-4d. per pound. Sierra Leone copal is second only to Zanzibar copal in hardness and well suited for varnishes where paleness, durability, and elasticity are important (HEDLEY BARRY). It is believed to owe its origin to the tree *Copaifera copallifera* (syn. *C. guibourtiana*), (*see* Kew Bull. 1934:400), which is also the source of a fresh resin, obtained by tapping, which has also been exported. This tree is widespread in Sierra Leone and other parts of West Tropical Africa, occurring from French Guinea to Nigeria. It is the most important copal yielding tree in West Africa and may yield resin copiously, particularly in the western areas of its distribution. The tree bears flat, one seeded pods, 1-1½ inches long, and leaflets in single pairs. Trees are tapped at the end of the rainy season while the sap is still flowing freely, by cutting squares of bark from the trunk at intervals, working upwards from the base. As the resin exudes it forms nodules 2-3 inches in diameter which are allowed to dry and harden during the dry season before being removed. Wasteful tapping or overtapping has caused much injury or mortality among trees in Sierra Leone in the past. In an attempt to reduce this, the Government at one period allowed tapping to take place only every third year. Experimental plantations of the tree have been established, but it is slow growing and requires about 10 years to reach a size suitable for tapping, which is slow for the tropics. In Sierra Leone the tree is known to the natives as "kobo" or "kubui" and in French Guinea as "kaki." Considerable quantities of the copal were exported at one time—1,000 tons from French Guinea in 1906 valued at 2-3 million francs (DE CORDEMOY).

Among other West African fossilized resins Cameroons copal, which has a hard lustrious fracture and a characteristic slight peppery odour, was considered to be the best of the West African copals. It is believed to be derived from *Copaifera demeusei,* the same botanical source as Congo copal. "White Angola" copal is probably from the same botanical source while "red Angola" (both fossil resins) is considered by some to be probably derived from *Copaifera mopane* (HEDLEY BARRY). This tree is widespread and very common in some parts of southern tropical Africa and is known as "ironwood" and "Rhodesian mahogany" on account of its hard reddish wood.

There is doubt regarding the botanical source of other West African fossilized resins and quite probably more than one species is involved in most areas. Both Benin (Nigerian) and Accra copals have suffered in the past through being badly cleaned and graded. Loango copal, which resembles Congo copal in general properties, occurs in globular or stalactitic pieces and varies from white to red in colour. Benguela copal, in its best grades, is light coloured and very hard. Gaboon copal may be light in colour or reddish. More detailed descriptions are given by HEDLEY BARRY and DE CORDEMOY. Among British possessions in West Africa the Gold Coast is considered to possess the best possibilities for future development of fossil copals.

Several species of *Daniellia,* common forest trees, yield resin freely in West Africa and are known to be the source of much of the fresh resin that has been collected and probably much of that procured in the semi-fossilized state. The outstanding species in this connection are *Daniellia oliveri, D. thurifera* and *D. similis.* The resin from these trees is fragrant and might well be termed a balsam or oleo-resin in the fresh state. It has been sold as copaiba balsam, being probably used as a substitute or adulterant for this product. The name "ogea" or "ujia" is commonly used in Nigeria for the resin of several species of *Daniellia. Daniellia oliveri* is a characteristic tree of the savannah forests or open country from Senegal to the Cameroons. Natives tap the trees to some extent by cutting out square pieces of bark. Sometimes a cavity is made in the trunk and a fire started in it. Natives use the resin to fumigate huts or to scent garments and kill vermin. It may also be chewed. Resin from *Daniellia oliveri* in Uganda (West Nile District) examined in London was found to be intermediate in properties between Manila copal and dammar and not to be of high commercial value. *Daniellia thurifera* has a wide range in the forest regions of West Africa and may be the chief source of West African copal (unfossilized), except on the Gold Coast, where *D. similis* seems to be the common species (DALZIEL).

East African Copal:—The East African copal trade is of very long standing for it is known that from an early date Arab traders exchanged this copal for cotton cloth with Indian traders. It was in the latter part of the 18th century that the trade was developed, mainly by the Portuguese. In the middle of the next century American merchants became active in the export of East African copal (HEDLEY BARRY). The better grades have been held in high esteem by the varnish maker on account of their hardness, being the hardest of all the copals. This secured for them an enhanced price during the time that natural resins were in keen demand and before the Congo copal industry came to be developed. At one time most East African copal was shipped from Zanzibar hence the name "Zanzibar copal" by which it was known in the trade. Later it came to be shipped direct from certain East African ports and acquired the names of "Lindi" or "Tanganyika" copal.

East African copal is derived almost entirely from the forest tree *Trachylobium verrucosum* (synonyms—*T. hornemannianum, T. mossam-*

bicensis) and may be collected from the living tree, from the soil in a semi-fossilized form, having dropped from trees still existant, or fossilized from areas where the trees no longer exist. It is the last mentioned which constitutes the best copal, that from the living trees being the poorest quality.

Trachylobium verrucosum is a tall evergreen tree reaching 70-80 feet, locally common in the coastal evergreen forest of Tanganyika and occurring also in Kenya. It has a smooth light coloured trunk with a flat bushy crown and bears shiny leathery leaves and white flowers in clusters. The fruits are about the size of a plum and have a warty surface on which resin may appear. Swahili names for the tree are, "mnyanza," "msandarusi," or "mtandarusi" (GREENWAY).

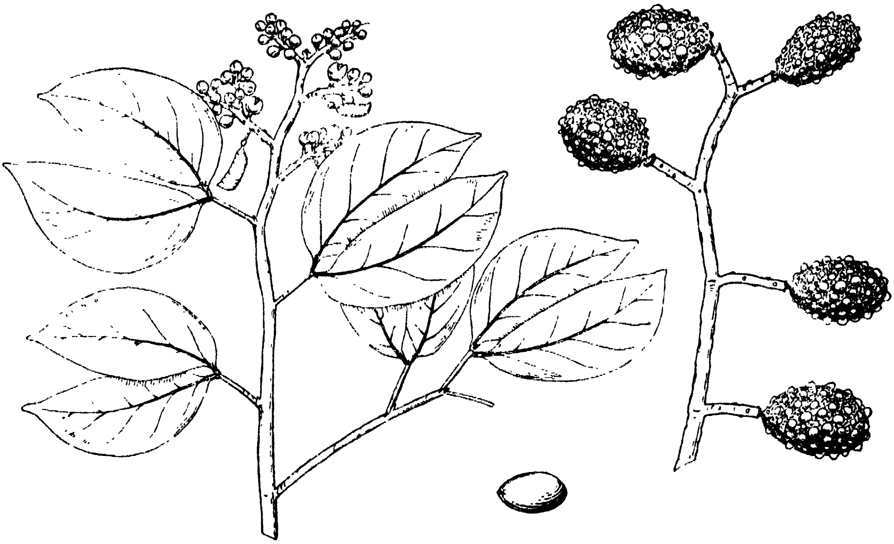


FIGURE 22.—**Trachylobium verrucosum** (Gaertn.) Oliv. The source of East African copal.

The fossilized resin is the sort mainly collected by the natives, the best areas being near rivers and streams, especially in the Lindi, Rufigi, and Bagamoya districts of Tanganyika. The soil is dug over to a depth of about 3 feet and the resin, usually in the form of flat or disc-like pieces, picked out and later roughly cleaned. The resin may be very pale, yellow or reddish in colour and often in quite large plates. A characteristic of the resin is its peculiar roughened surface, "goosekin" as it is termed, which serves to distinguish it from all other copals. The reasons for this "goosekin" are not well understood, although it is thought it may be connected with alkali salts in the soil having a solvent action.

The fruits of *Trachylobium verrucosum* contain an appreciable quantity of copal, but this is not easily obtained or extracted. It has been estimated that 500 kgm. of fruits contain about 100 kgm. of copal. No attempts at cultivating the tree on a large scale appear to have been made, but an individual tree cultivated at Amani in Tanganyika was found to be 5½ m. high when 5½ years old with a circumference of 46 cm. at the base (A. ZIMMERMANN 1908).

Madagascar copal resembles that from East Africa in hardness and other characters, but does not show the characteristic "goosekin". It is collected from the soil and may be present in large deposits mainly in the north part of the island. This copal is considered to be derived from the same botanical source as the East African. Resin may also be obtained by tapping (DE CORDEMOY).

In the latter part of last century a good deal of interest was directed to what was then a new copal termed "Inhambane" copal (*see* Kew Bull. 1888:281). This proved to be quite different from ordinary East African copal in appearance and properties, and resembled more closely Accra copal. It was later shown to be derived from *Copaifera gorskiana,* a common tree in parts of East Africa.

Resin resembling a dammar more than a copal has been collected from *Daniellia oliveri* in Uganda. The fragments, covered with a white oxidised crust, varied in size from a pea upwards and were easily broken between the fingers exposing a vitreous fracture. The internal colour varied from pale yellow to dark amber. This resin had a high acid value and was only slightly soluble in alcohol. It was not considered to be of much commercial value (Bull. Imp. Inst. **36**:463-6).

South American Copals:—From time to time in the past, consignments of South American copal have appeared on oversea markets, being usually known by the country of origin—"Brazil," "Para," "Demarara" copal, etc. Brazil copal is sometimes in pebble form as though recovered from water courses and varies in size from a pea to a man's fist. When dug up from the ground it may be in large irregularly shaped pieces. The source of this resin is believed to be mainly the West Indian "locust" or "courbaril" (*Hymenaea courbaril*), although other species of *Hymenaea,* of which there are about 30 in tropical America, may be responsible for some of the resin collected.

Among the species of *Hymenaea* reputed or believed to yield resin to a greater or less extent in different parts of Brazil, in addition to *Hymenaea courbaril* are the following—*H. courbaril* var. *obtusifolia* (Belem, Almeirim), *H. intermedia* (Obodos, Jamundá), *H. parvifolia* (Tapajoz, Tocantin area), *H. velutina* (Maranhao, Piauhy), *H. stigonocarpa* (Northern States), *H. stilbocarpa* (Middle and Southern States). All are trees of fair dimensions and yield good or much prized timber. The common native names for them are "jatoba," "jatahy," "jutahy" and "jatahyba," and for the resin "jutahycica." The resin is not collected at any special period of the year and apart from what may be used locally the bulk of that exported has in the past found its way to the United States. (F. W. FREISE 1934). The fresh resin obtained by tapping the trees is much softer than that dug up from the ground, and is in the nature of a balsam or soft elemi and has medicinal uses.

Hymenaea courbaril is a well known and widely distributed tree in the American tropics and also yields valuable timber. It may reach 100 feet in height and have a lofty trunk 6-8 feet in diameter above its large buttresses. The leaves are composed of a pair of leathery leaflets about 3 inches long. The large flowers are white or purplish and the pods massive and thick-walled with seeds embedded in a sugary, sometimes resinous pulp. This is often eaten. The pale yellow or reddish resin exudes from the bark and trickles to the ground to collect or harden into lumps and eventually become covered with soil. In the course of time resin may collect in this way in considerable quantity. Native collectors may obtain a barrel full of copal by digging around the roots of a tree, and several barrels may be secured by digging what was doubtless the former site of a large tree long since decayed. The older the resin the better is its quality and hardness likely to be. Some very large lumps of this resin are in the Kew museum.

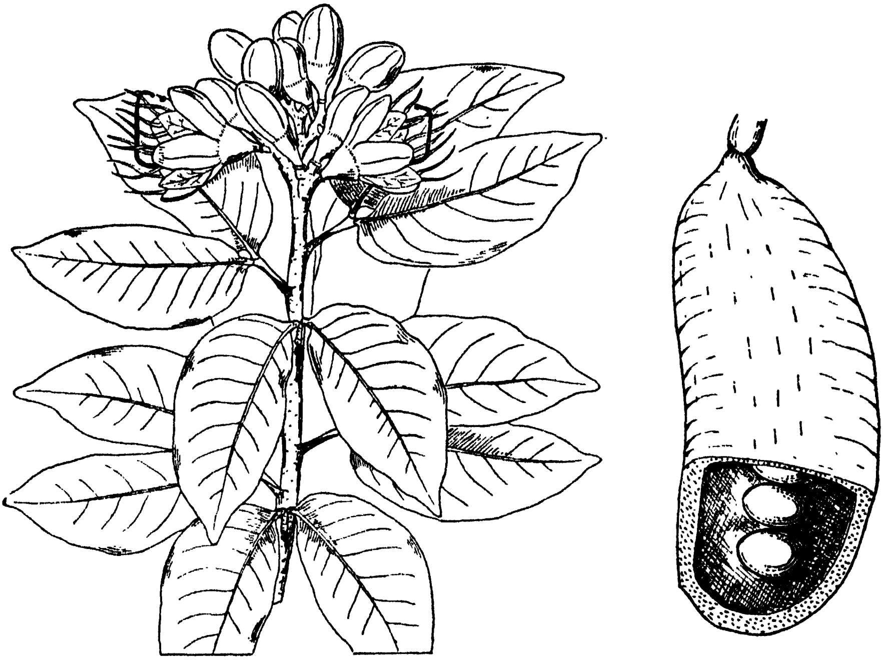


FIGURE 23.—**Hymenaea courbaril** L. (West Indian Locust). A source of South American copal.

South American copal is usually of good colour and transparency, but on the whole softer than the African and East Indian copal and has not found much favour in the United Kingdom. The resin is said to be difficult to process or "run" and the loss high. Furthermore, in the running process it is liable to froth and cause fire unless carefully handled (HEDLEY BARRY).

East Indian and Manila Copal:—The East Indies and the Philippines have been important sources of copal in the past, the main export centres being Manila, Singapore and Macassar. At one time Manila was the source of most of the copal exported from this region, hence the name "Manila copal" that came to be used for it. Later Celebes and the Moluccas produced greater quantities of copal than the Philippines (exported in the main from Macassar) but the term "Manila copal" is still often applied to it. The total production of East Indian or Manila copal in some years has been in the neighbourhood of 15,000 tons.

Unlike the other copals so far discussed, East India or Manila copal is derived from a single botanical source—*Agathis alba*—a tall forest tree reaching 200 feet in height, closely allied to the "kauri gum" of New Zealand and widespread in the East Indian region. It occurs throughout Malaysia from Sumatra to the Philippines, Moluccas and on into New Guinea. It is present also in Cochin China. In Java it is not indigenous although sometimes cultivated (van de Koppel), and in Malaya is not abundant and occurs only at the higher altitudes. In general, the tree is much more prevalent in the eastern sphere of its distribution than in the western and grows to a greater size there. In the southern islands of the Philippine group it is a very common tree. The tree is considered to reach

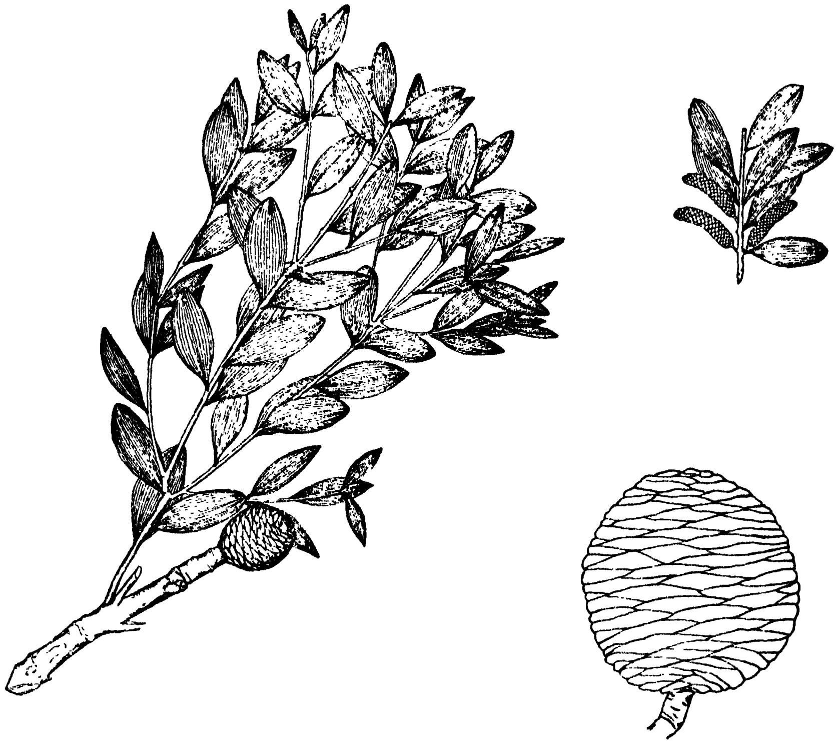


Figure 24.—**Agathis alba** (Lam.) Foxw. The source of East Indian and Manila copal (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by West and Brown).

a good age, up to 500 years, although the kauris of New Zealand may reach three times this age. It varies somewhat in appearance from place to place, and is found in all manner of soils. The tree is a typical Conifer and commonly grows with the smooth, round trunk, which may be 6 feet or more in diameter, unbranched to a considerable height and without buttresses. The crown is usually conical in shape, but may be flattened and the leaves grey or olive green in colour with a leathery texture. The bark, which flakes off, is brownish red and 1-2 cm. thick and the timber very like that of New Zealand kauri. It is from the living bark that the resin exudes when the tree receives an injury or is tapped.

The copal from the tree may be collected in one of three forms—in a fossilized state from the earth, as large lumps in the forks of trees, or from recent tapping. At one time practically all the East Indian copal that entered world commerce was that recovered from the soil, but later as accessible areas were worked over, supplies became short and that collected from the forks and branches of large trees took its place. In time, this source grew less and supplies of the resin were obtained by tapping, particularly in Celebes and the Moluccas where this method of obtaining the copal made great headway two or three decades ago. Such copal is softer than that dug up from the earth.

In obtaining the resin from the ground, the natives employ an iron tipped shaft, as in the Congo, and from the sound and the resistance this offers when an object is struck are able to tell whether a lump of resin has been encountered. Very large pieces of this copal are often recovered from the soil and the methods whereby they form have been the subject of some speculation. It is obvious that lumps that form on the ærial parts of the tree may reach the soil when the tree eventually dies and falls in the forest. However, apart from this it is known that the rootbark may secrete resin freely. It is believed by some that roots may decay and the cavities they leave become filled or partly filled with resin (VAN DE KOPPEL).

The lumps of resin obtained from the forks of large trees may be massive and weigh up to 20 kgm. Climbing large trees to obtain the resin is both difficult and dangerous for the native collectors who often will not undertake the work unless prices are good, or they are themselves very short of money. The smooth unbranched trunks offer little or no foothold and various devices are employed to ascend the trees. It is thought that the resin in the forks in most cases owes its origin to high wind and storms causing cracks or fissures in the wood and bark from which the resin flows and accumulates.

Good accounts of the tapping and collection in the Dutch East Indies have been given by HEYNE and VAN DE KOPPEL, while FOXWORTHY and others have described the tree and its exploitation in the Philippines where a common name for it is "almaciga." Latterly, only high grade Manila copal has been exported from the Philippines, the amount exported in 1940 being valued at 200,000 pesos (1 peso = 50 cents U.S.A.). A chemical method (embodying the use of hot alcohol and filtering) has been devised for converting the low grade into the high grade copal (TANCHICO and WEST 1940).

In the Celebes, the hard copal taken from the ground or the forks of trees is termed "boea" ("white boea" from the trees and "brown boea" from the ground). That obtained from tapping is termed "loba" if it has remained on the tree for some time and has hardened, and "melengket" if it is still soft and from but recently tapped trees. These names are Malay names but are used commercially in Macassar. "Melengket" is a soft spirit soluble resin and "loba" a half hard, partly spirit soluble one. By the process of ageing and hardening therefore "melengket" becomes "loba." The former is not collected over two weeks from tapping and the latter in less than a month from tapping. In some districts where concessions are made, an individual native having the right to tap 50-200 trees, the resin is allowed to harden into "loba" before collection. In others where there are no such rights or concessions and the resin liable to be removed or stolen by others, the tapper removes it in the "melengket" stage.

In tapping, a horizontal cut 15-30 cm. long is made and the bark below this removed for about 30 cm. so that the resin has a clear surface on which to flow and dry. When the bark is not removed and incisions only made the resin is not clear and is adulterated with pieces of bark. The wound may be enlarged in an upward direction at later intervals to prolong the flow. Over-tapping of the tree often takes place, too much bark being removed at ground level and not enough higher up the trunk. The higher tapping is reputed to yield more resin, but entails much more labour. The horizontal cuts should not exceed one half of the circumference of the tree. Yield varies according to the size of the tree. VAN DE KOPPEL estimated that the average annual yield of the 200,000 trees tapped in the Malili district of Celebes was approximately 12 kgm. per tree. In Borneo a special method of tapping for the production of Pontianak copal (a high grade copal) consists of severing the ends of the branches, the resin exuding from the cut surfaces.

In collecting the resin or "loba" it is chopped off with a hooked knife and falls into a small basket. It is packed in *Pandanus* baskets and taken to the merchants. Before export it is graded and sorted, the work being generally done by women at the ware-houses of different shippers. The "boea" or hard copals are the easiest to sort as they do not block in transit. The earthy crust is removed with a knife and the pieces then graded for size and sometimes for colour. With the other sorts ("loba" and "melengket") the blocks have to be broken with a hammer, after which grading is mainly for freedom from impurities.

In the Celebes the copal is used a good deal by natives for the making of torches as much fishing is done by night. In preparing these, the copal is first softened over a fire and then rolled into sticks the thickness of a finger and covered with palm leaf. Several such pieces are used for a torch.

In Malaya and some parts of the Dutch East Indies the tapped resin of *Agathis alba* never really hardens for some unknown reason and is known as "syrup copal". The Malayan name for it is "damar minyak."

The main commercial use for East Indian copal has always been for varnish manufacture, especially for high grade or quality varnishes. In general the resins of *Agathis* are a little too soft for oil varnishes but are used in spirit varnishes, and for lacquers and linoleum manufacture. A good account of their chemistry has been given by HEDLEY BARRY. The same writer lists other commercial varieties of East Indian copal such as— "Labrian," "Zambas," "Lowoe," "Gorontalo" and "Ternate."

Agathis alba has been cultivated as an ornamental tree (*e.g.* in Java), but not for resin production and it is unlikely that the latter would prove profitable, the tree being relatively slow growing.

Resin has been obtained from certain other species of *Agathis* besides *A. alba* and *A. australis, e.g. A. brownii* (syn. *A. robusta*) (Queensland) *A. moorei* and *A. ovata* (New Caledonia), *A. macrophylla* (Solomon Islands) and *A. vitiensis* (Fiji).

Chapter IX

ROSIN OR COLOPHONY

The natural oleo-resin of pine trees (*Pinus* spp.), obtained by tapping or chipping the trunks, yields on distillation two important products—turpentine and rosin, the latter being sometimes termed colophony. Other conifers in addition to species of *Pinus* may be induced to yield oleo-resin in sufficient quantity for exploitation, but they are of little importance and practically all the rosin of commerce is derived from pines. In addition to the collection of oleo-resin from the living stems by repeated tapping, scarring or chipping, colophony and turpentine may also be obtained by distillation of pine stumps, knots, waste wood and saw-mill refuse. The rosin and turpentine so obtained are fundamentally the same as those obtained from the living tree, the terms "wood rosin" and "wood turpentine" being applied to them. Only a small proportion of the world's supplies of rosin and turpentine are obtained in this way, and the distillation of pine stumps and waste wood is only practised in the more progressive regions.

Oleo-resins are present in the tissues of all pines but not all respond sufficiently well to tapping or "turpentining" for systematic collection to be worth while. Not more than a dozen and a half different species are regularly worked for their oleo-resin in various parts of the world out of a total of about a hundred species in the genus *Pinus*. The bulk of the world's supplies are produced by three or four species only. In general, it is the trees in the warmer areas of distribution rather than the cold northern latitudes that yield the oleo-resin most freely. The proportion of turpentine in the oleo-resin is usually in the neighbourhood of 20%, but varies much with different species of pine and with climatic conditions.

The uses of rosin are largely governed by its grade or quality. The superior grades are used in pale varnishes and to a small extent in pharmacy in the preparation of plasters, ointments, etc., while the medium grades are largely used in soap manufacture. Large quantities of rosin are employed in paper sizing, the medium or lower medium grades being used for this purpose. The poorer, darker grades are employed in linoleum manufacture and distilled to yield "rosin spirit" and "rosin oil". It has been estimated that about 28% of the rosin produced is used for soap, 23% in paint and varnish making, 7% in rosin oil, greases and printing inks, 4% in sealing wax and insulation and about the same quantity in linoleum oil cloth and roofing. Small amounts are also used in the making of steel and iron, chemicals and matches (L. WYMAN 1929).

The Industry in the United States:—For more than a century the United States has been the world's largest producer of rosin and turpentine, often referred to as "naval stores." This term originates from the early days of the 17th century when the wooden sailing vessels then in use employed large quantities of tar and pitch from the Coniferous forests of northern Europe. The amounts of these products now used for maritime or naval purposes has dwindled to small proportions, but the old name "naval stores" still persists. The United States produces between 60 and 70% of the world's supplies of rosin and turpentine. France is the next largest producer with about a third of the amount produced by the U.S.A. The United States industry represents an annual output of some fifty million dollars, estimated to be derived from about a hundred million trees (A Naval Stores Handbook, U. S. Dept. Agric., Misc. Pubn. No. 209).

The rosin and turpentine industries of the United States are located chiefly in the south east, in the eight coastal states from North Carolina to Texas. In the early days, production was mainly in the Carolinas, but as the more accessible pine woods became exhausted as a result of the destructive methods then employed, the pine woods in the adjoining states received attention. Florida is now the most important state for production and supplies about 36% of the total U.S. output of "naval stores," or 25% of world production (WYMAN). The two pines exploited in this south eastern region are the longleaf pine (*Pinus palustris*) and the slash pine (*P. caribaea*), the former yielding the bulk of the resin. Approximately 52 million acres of potential longleaf and slash pine land lie in the south east corner of the United States where the soils are mostly sandy and of poor fertility but well suited for pine forest, and the climate warm and equable.

Longleaf pine, known also as south yellow pine, Georgia pine, hard pine, hill pine and longstraw pine, tends to grow in pure stands and in its early years grows more slowly than slash pine. Once growth starts the tree may increase in height 2-3 feet a year in good soils. Characteristics of the tree are the length of the needles or leaves (8-18 inches), the large cones (6-10 inches long and 2-3 inches in diameter) and the conspicuous large silvery white buds ("candles").

Slash pine is one of the most rapid growing forest trees of North America. Besides the area already indicated it also occurs in Louisiana, Honduras, Eastern Guatemala, Nicaragua, Bahamas and Cuba (G. B. SUDWORTH 1927). It is sensitive to fire in its early years and is easily damaged by bad tapping or chipping. With heavy chipping it is much more prone to "dry face" or cease yielding than is longleaf pine. It usually grows in combination with other pines and not in pure stands. The fact that slash pine gives relatively high yields of "gum" and that this is more liquid and forms less crust or "scrape" on the face than is the case with longleaf pine, are points in its favour. It is believed that these factors, combined with the spread of the species through increasing fire protection, may cause it to play an increasingly important part in the production of naval stores in the United States (A Naval Stores Handbook).

Other North American pines that have been "turpentined," either experimentally or on a small scale, in the United States, but which are of no importance commercially in this respect are:— loblolly pine (*P. taeda*), shortleaf pine (*P. echinata*), pond pine (*P. rigida*), ponderosa pine (*P. ponderosa*), piñon pine (*P. cembroides* var. *edulis*) (syn. *P. edulis*), sugar pine (*P. lambertiana*) and lodgepole pine (*P. contorta*).

In the early days of the pine resin industry in the United States, the destructive "box" method of obtaining the resin was alone practised. This consisted of cutting a hole or box into the base of the trunk at ground level, to collect the resin that would later flow from the face chipped on the trunk immediately above it. Gradually the face was extended upwards and the resin collected or dipped out as it accumulated in the box. This drastic treatment of the tree frequently led to its decay or untimely death, or to being blown over. Improved methods of tapping, embodying the use of collecting cups or receptacles, along with light chipping in making the face, have largely superseded it. An important advantage of the collecting cup is that it may be moved upwards as the face is extended with the result that the resin does not have to traverse the full length of the face. There is less "scrape," less evaporation of the volatile turpentine constituents, and the resulting product is cleaner. Various special keen-edged tools are used in chipping or working the face on trees to be turpentined and for inserting the metal gutters or aprons to direct the flow of resin to the collecting cup or receptacle. The latter may be rectangular in shape and made of metal, or of earthenware and shaped like a flower pot. They may be attached to the trees by various means, often hung on a nail. Men engaged in the work commonly function in crews for greater efficiency. During the collecting season (March to November) each tree is chipped about once a week to induce the continued flow of resin. It is considered that faces should not be wider than one third the circumference of the tree and that trees less than 9 inches in diameter should not be tapped. In France and in India the faces are much narrower than those usually cut in the United States.

The semi-liquid oleo-resin that collects in the cups (commonly termed "dip") is collected from time to time as the cups become nearly full. This is usually about every four weeks. The more frequent the "dipping", the less loss of turpentine there is likely to be from evaporation. The cups are emptied into a bucket with the help of a dip-iron or wooden paddle. When the bucket is full it is emptied into a barrel and the barrels eventually transported to the still by mule team, motor vehicle or rail. The dried oleo-resin or scrape that collects on the face is removed periodically. The older methods of distillation consisted of using large copper stills holding 9-10 barrels of crude oleo-resin and heated by direct fire. A small quantity of water is run into the still to facilitate distillation. When all the turpentine has distilled over, the excess water is boiled away and the rosin run through wire filters into barrels and is ready for shipment. On an average, barrels hold about 420 lbs. of resin. There are some fourteen recognised grades of American colophony, based mainly on colour. These are known by letters, the best grades being "WW" (water white) and "WG" (window glass). The poorest grades, "B", "C", etc. are very dark or almost black. Improved methods of distillation embody the use of high pressure steam and distillation under vacuum.

The Industry in France:—The history of the important French turpentine and rosin industry goes back to the latter part of the 18th century when proposals were made to reclaim and cultivate pines in the triangular piece of territory in the south west of France bounded by the Bay of

Biscay on the one side and roughly by the Garonne and Adour rivers on the other. Centuries ago this region was covered by natural or virgin forest, but the timber was gradually depleted and the country given over largely to grazing. This, combined with fires which swept the area, resulted in steady depletion of the vegetation, and drifting sand, partly blown in from the exposed sea coast, slowly covered the area. Farms and even towns were buried by the sand, waterways and drainage blocked. Cultivation became impossible and eventually the region became quite unproductive, being water logged in winter and covered with mists in summer and the inhabitants subject to the ailments and disease that such conditions induce. The planting of pines was started by BRÉMONTIER in 1803. This, combined with the successful drainage of the area, converted the once barren district into the centre of an important industry with a large and healthy population. The results stand as a fine example of reclamation work and of man's success in improving his environment. Over a million hectares are now devoted to pine cultivation in this part of France, made up as follows:—les Landes 516,000: la Gironde 462,000: le Lot et Garonne 100,000: les Charentes le Dordogne 100,000. The chief business centres of the industry are Dax and Bordeaux. There are also some 200,000 hectares in Provence (H. FINNEMORE 1926).

The maritime or cluster pine (*Pinus pinaster*), which is native to the region is the species mainly cultivated, although the Aleppo pine (*P. halepensis*), which grows well along the Mediterranean coast, is also used to a small extent. As the name suggests, the maritime pine is well suited for growth near the sea, and is one of the best pines for light sandy soils. It has a fairly rapid rate of growth. There is a tendency for the tree to be much branched. When growing near the sea, the trunk is often twisted and gnarled. Nevertheless, such trees may form a valuable windbreak or screen for trees further inland, enabling them to make better growth. Another of the characteristics of the tree is that the cones are born in whorls, are deflexed, and may persist for several years. The timber is inferior to that of many pines. Seed is usually produced freely and natural regeneration takes place readily in the absence of fires.

The success of the French industry is due in the main to the efficient forest management that has been practised with pine forests over a period of several generations. Land ownership is of all types. About a fifth of the land is Government owned and administered by trained foresters. Some is the property of towns and "communes" and a good deal under private ownership. Private estates of 5,000-10,000 acres are met with, some with their own mills and distillation plants. Small private holdings are general. It is common for the owners of the trees not to do the turpentining themselves, but to hand this over to a still owner or other operator, the proceeds being shared. Operators and owners have their own organizations and operators usually take a personal interest in the woods as they have much to gain in the long run from their continued welfare.

The forests are managed in such a way as to procure sustained resin yield along with the maintenance of health and vigour of the trees. This management falls roughly into three main phases. The first 20-year phase, which yields practically no monetary return, consists of natural reseeding and growth of seedlings in an area where old exhausted trees have been removed. In these, no thinning is usually done until the trees are 5-6 feet high, after which thinning is done at about 5 year intervals. At 20 years the remaining trees, numbering some 300-400 to the acre, have attained a height of about 40 feet and a diameter of 6-7 inches. The second phase then commences. In this the unwanted trees are turpentined severely (*gemmage à mort*) and then cut out and sold as mine props or pulp wood, leaving a stand of 80-100 trees per acre. In the last phase these remaining well spaced trees are tapped on a conservative basis for the remainder of their 60-70 years of useful life. This includes a succession of workings (*gemmage à vie*) with only one or perhaps two narrow faces per tree at a time, so as to retain the health and normal growth of the tree as far as possible.

The French method of turpentining differs in many respects from that in the United States and different tools are used, but nevertheless, the basic principles are similar. Clay cups holding rather less than a quart are used for collecting the resin and a metal gutter inserted immediately above the mouth of the cup. In earlier days, instead of making holes in the base of the trunk to collect and hold the resin as in the U.S.A. ("boxing"), a small hole was made in the ground at the base of the trunk for the resin to flow into. This results in a very much inferior product to that obtained with cupping. There is naturally a much greater loss of turpentine and higher percentage of impurity present.

A good deal of skill is required for efficient chipping and the youths in the pine districts of France acquire it from their elders in a long apprenticeship in what will later be their life work. In commencing to work the trees, the rough bark where the face is to be is first removed, usually a winter task. To start a face, living bark and wood are chipped away in a strip 4 inches wide and 1½ inches deep near the base of the trunk. At each subsequent chipping the height is increased about ½ inch and the old face may be freshened up. The depth of chipping is nowhere deeper than ½ inch into the wood. At the end of the season the face is about 30 inches high. Each face is worked for four seasons. When it becomes out of reach a light ladder is used. An experienced worker can chip and collect the resin from about 7,000 faces in a season. A yield of 13-30 barrels of turpentine, or an average of 20, with the corresponding rosin, may be expected from 10,000 faces. The main classes of French rosin are known as "brais" (the equivalent of the American "A-G" grades: "colophanes" (equivalent to the U. S. "H-M" grades): "supérieures" (equivalent to the U. S. "WG" and "WW" grades) and "bleached."

Rosin Production in other European Countries:—

Spain and Portugal.—Next to the United States and France in importance as producers of rosin and turpentine stands Spain with a production of 6-7 per cent of world supplies or about a third that of France. The industry developed about the middle of last century and the districts mainly worked are those in the centre of the peninsula around Madrid. In the early days destructive exploitation caused much damage to the trees but later the improved French methods were adopted and the industry run on very much the same lines as that of France. A good deal of the land is Government owned and the forests now run on efficient up-to-date lines. As in France the maritime pine or "pino negral" (*Pinus pinaster*) is the species mainly worked but the Aleppo pine or "pino carrasco" (*P. halepensis* and Corsican pine *P. nigra* var. *calabrica* (syn. *P. laricio*) which grows mainly along the Mediterranean coast, are also tapped. Only a proportion of the total available area has so far been worked. Difficulties of transport have often proved serious obstacles to exploitation.

Much of the Spanish rosin is of very high quality, often superior to the American "WW" grade and the turpentine equal to the French. The practice of sun bleaching the rosin in zinc trays is carried out more than in France (HEDLEY BARRY). About half the Spanish output is consumed by the home market.

In Portugal the production of rosin and turpentine has developed very much during the present century. The pine forests, occupying close on three million acres, are situated mainly in the centre of the country. Only a small proportion have been tapped. The principal tree is the maritime pine (*P. pinaster*) but the stone pine (*P. pinea*) has also been worked. The French methods of tapping are employed but frequently the faces are wider and the chipping deeper. Portugal occupies fourth place in world production of rosin but her contribution is only some two per cent.

Greece.—The production of pine resin in Greece from the Aleppo pine (*Pinus halepensis*) goes back to early times. Up to the present century the natural oleo-resin was mainly employed in the wine industry, being added to give a characteristic flavour and improve the keeping quality of the wine. In more recent times much attention has been given to the production of rosin and turpentine and the output much increased. The main forests are in the Attika, Eubia and Argolis districts. The trees are often widely scattered and with inclined, not straight, trunks. In recent years the Greek output has varied between one and two per cent of world supplies, much of the rosin going to Italy and the turpentine to Germany.

Russia.—In Russia the production of rosin and turpentine in the past has mainly been by distillation of the wood rather than the tapping of the living tree, but the latter is now receiving increased attention. The predominating pine in the vast forests of European and Asiatic Russia is *Pinus sylvestris* ("Scot's pine"). This species is not usually considered among the best for oleo-resin production (A. OUDIN 1938) although it has been tapped in parts of Russia and in other European countries. The most satisfactory results in pine tapping appear to have been in south Russia. In some parts of Russia a form of tapping, in which collection is carried out only about twice a year, has been practised with *Pinus sylvestris* with the primary object of obtaining a wood richer in oleo-resin for distillation.

Germany.—As in Russia special attention has been given in Germany to the exploitation of *Pinus sylvestris* for oleo-resin, particularly in times of war when the usual sources of rosin and turpentine are cut off. Attempts have been made to increase the flow of oleo-resin from the face by applying stimulants. Success has been claimed by one worker with experimental tapping by the use of 25% hydrochloric acid (Annual Report Schimmel & Co., 1936:84), but this does not appear to have developed beyond the experimental stage.

Austria.—In parts of Austria the tapping of the Corsican pine (*Pinus laricio*) for oleo-resin has been carried out for several decades but the area worked, estimated at 40,000 hectares, and the quantity of rosin and turpentine produced has never been very large.

Production in India and the East:—

India.—The idea of tapping the extensive Himalayan pine forests for rosin and turpentine may have arisen from observing the extraction of the crude oleo-resin by local tribes. For ages the hillmen are known to have tapped or exploited the trees, albeit in a wasteful fashion, to meet their own small requirements, being interested primarily in the rosin which was used medicinally and in other ways. *Pinus roxburghii* (syn. *P. longifolia*) ("chir") is the most important pine in the Himalaya region and covers extensive tracts in north west India. It is this species that has been mainly tapped for rosin and turpentine and is the basis of the Indian industry.

Systematic tapping was initiated by the Indian Forest Department in about 1889 and the industry has been built up by a succession of Government forestry officers, many of whom, in the early days, had received their training or part of it in France and were familiar with French methods of turpentining. The French "cup and lip" method, with light continuous tapping and the narrow French "face" are the methods that have been adopted. A good account of the early history and development of the Indian industry has been given by E. A. SMYTHIES (1914) while F. C. FORD ROBERTSON (1939) has described the more recent improvements that have taken place, particularly in regard to field practice. That the resin industry is of some importance in India may be gauged from the fact that in the United Provinces alone the annual profits since 1908 have ranged from one to two lakhs of rupees and half as much again has been paid in wages every year. Tapping has also been done in Kashmir and the Punjab.

The long-leaf or "chir" pine (*Pinus roxburghii*) is a large, stately tree, partly deciduous, and with thick bark (1-2 inches) cut by fissures into irregularly shaped plates generally about 6 inches across. It has long needles (9-10 inches) and large woody cones. The tree is widely distributed in the outer Himalayas and the principal river valleys of the Himalayas at altitudes of 1500-7500 feet, extending west to Afghanistan and east to Bhutan. It may occur in pure or mixed forests, some of the former being as much as 100 square miles in extent. The rate of growth is extremely variable ranging from 15-20 rings per inch to 2-3, with an average of 6-12 (J. S. GAMBLE 1922). The tree is longer lived than the maritime pine (*P. pinaster*) and has a longer rotation in forest practice. Apart from occurring in greater abundance than any other Indian pine it is claimed to yield resin more freely.

The transport of the crude oleo-resin from the tapping areas to the distillery has been one of the main difficulties in developing the Indian industry. The distances are often very great and the roads poor. Pack animals and human transport are often employed in the more inaccessible regions. Most of the resin is finally conveyed to the distillery by bullock cart. The distilleries themselves are situated some 700-800 miles from the nearest sea-port which means heavy freight charges on the finished products intended for export. Nevertheless exports to Europe, China and the Dutch East Indies have reached important dimensions.

In the Kumaon area the most notable advances in recent years are claimed (FORD ROBERTSON) to be the use of improved tools and a stricter and more intensive control of tapping and other field work. More care is now paid to the best location for a face on the trunk and to making the best possible use of all the tapping surface of the tree that is within easy reach of the tappers. In this connection the initial blaze or face has been reduced from 6 × 3¾ inches to 4 × 3¾ inches. Specially devised fool-proof scribes are used for marking the trees so that the coolie finds everything ready for his adze. Improved forms of "pattris" (channel aligning boards), scribes, lip-pullers and channel gauges are now in use. Locally made earthenware pots with a nail hole are used to collect the resin as it flows from the face.

Most of the rosin produced in India is used locally in soap manufacture while a good deal of the turpentine finds its way to the Indian railway workshops.

Four other pines occur in India but none are likely to be as important as the chir pine for resin. *Pinus wallichiana* (syn. *P. excelsa*), the blue pine, occurs in the temperate Himalaya from 6,000-12,000 feet. Rosin and turpentine from it are claimed to be superior to that from chir but not yielded so freely. It has been tapped in the Punjab. The Khasia pine (*Pinus khasya*), which forms forests in the Khasia hills and in the Martaban and Shan hills of Burma is rich in resin known to yield good quality turpentine, but it occurs mainly in inaccessible areas. *Pinus merkusii* also occurs in the Shan States and Martaban but has not yet been exploited for colophony, although a source elsewhere in the eastern tropics. The remaining species, *Pinus gerardiana* of the western Himalayas and Afghanistan, does not appear to have been tapped for resin.

Dutch East Indies.—In recent years increasing attention has been given to the production of resin and turpentine from *Pinus merkusii* in Sumatra. A good account of the results obtained has been given by D. G. MOON (1942) and much of what follows has been abstracted from his remarks.

Pinus merkusii has been described as the most tropical of all pines. It has a wide distribution in the eastern tropics, extending to northern Burma, Indo-China and the Philippines. In the Dutch East Indies it occurs only in the mountainous parts of northern Sumatra at altitudes ranging from 1500 to 7000 feet. Rainfall and humidity are high and there is a relatively small range in temperature throughout the year. Growth is rapid and more or less continuous, assuming damage from fire or animals does not occur. This results in the absence of definite annual rings as is usual with pines. In northern Sumatra trees may reach 200 feet in height and 11 feet in diameter, with tall straight boles. Normally the trees are scattered and not in pure stands as is sometimes the case with the Indian pines. Seedlings from natural regeneration are said to appear mainly on cleared areas, on land slides on the mountains, etc. but do not appear to develop in the shade of the hardwoods. In cleared areas, in the absence of fire, second growth may be extremely rapid and approximate to 5 feet per annum.

In 1924 the Government in Sumatra first decided to commence experiments on the growth of the pines for turpentining and placed control under the Government Plantations Department. Demonstration plots were established. Experiments in thinning and tapping, etc. started. Pines from other parts of the world were also tried but none proved so satisfactory as *Pinus merkusii* under Sumatran conditions. It was soon found that the young second growth trees of *P. merkusii* were much more satisfactory for turpentining than the scattered older trees often injured by fire at some time and competing with other trees. Ten years later (1934) a small commercial enterprise had been started yielding some 600 tons of colophony a year. By the end of 1941 output had reached 12,000 metric tons.

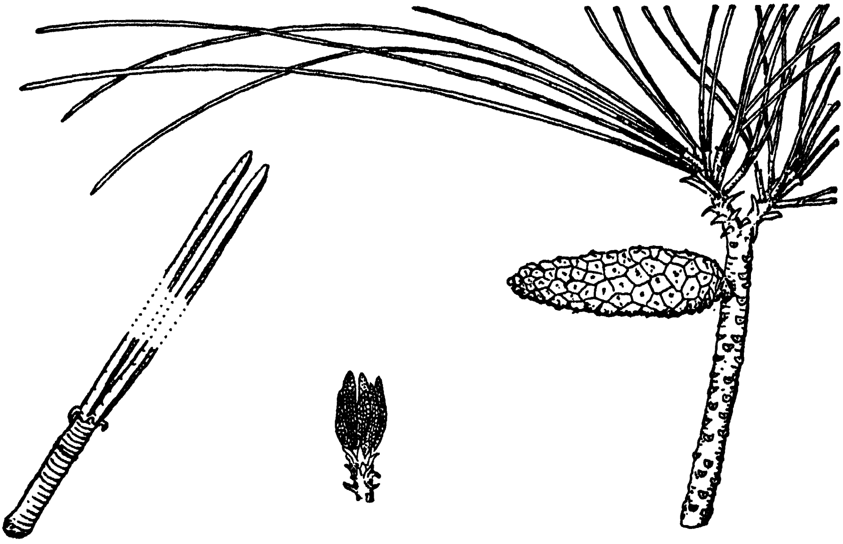


FIGURE 25.—**Pinus merkusii** Jungh. et de Vr. A widespread pine in the eastern tropics which has now been exploited for resin and turpentine in Sumatra (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by WEST and BROWN).

The rosin is collected at various points, averaging some 50 miles from the central distillery and is transported by motor truck. The prepared resin (grade "X") is packed for export in 100 kgm. boxes and the turpentine in 200 litre drums.

Tapping follows the French or Bordeaux methods, using a narrow face, and with certain modifications for local conditions. Aluminum cups, with wooden lids to reduce evaporation, have been used. Trees are first tapped when about seven inches in diameter and about eight years of age. usually numbering some 700 to the hectare. When the diameter reaches 12 inches a second face is started. Fresh cuts are made every third day. In thinning, certain selected trees are tapped to death before being cut out as in the Llandes region. The rapid rate of growth necessitates frequent thinning—every second year. It is considered a final stand of about 100 trees per hectare will be found desirable. If the trees are over thinned in the early stages there may be a tendency for crooked stems or trunks to develop. It is believed established stands would yield about 750 kg. per hectare or 680 lbs. of colophony per acre.

Special attention has been given in Sumatra to the use of thinnings for pulpwood for which the timber of *Pinus merkusii* is well suited. The best methods of working the stands or young plantations for rosin and for pulpwood must depend to some extent on the demand and the relative prices of the two products.

Philippines.—Pine resins have been exploited to only a small extent in the Philippines, the pines in question being *Pinus merkusii* and *P. insularis* (Benguet pine). The latter species is stated to have been used in Spanish times as a commercial source of turpentine (A. P. West and W. H. Brown 1920). This tree forms extensive forests in the mountainous regions of northern Luzon at altitudes varying from 500 to 2500 m. It reaches 40 m. in height with a diameter of 140 cm. and usually has a straight clear bole. It was found possible to tap the trees throughout the year, resulting in a higher yield per tree than is usual in the United States where there is no tapping for several months during winter. The yield per tree is known to vary considerably and the rosin obtained from different trees was found to differ somewhat in composition. The rosin when freshly prepared was pale yellow with a slightly aromatic odour (I. de Santos, A. P. West and J. Fontanoza 1931).

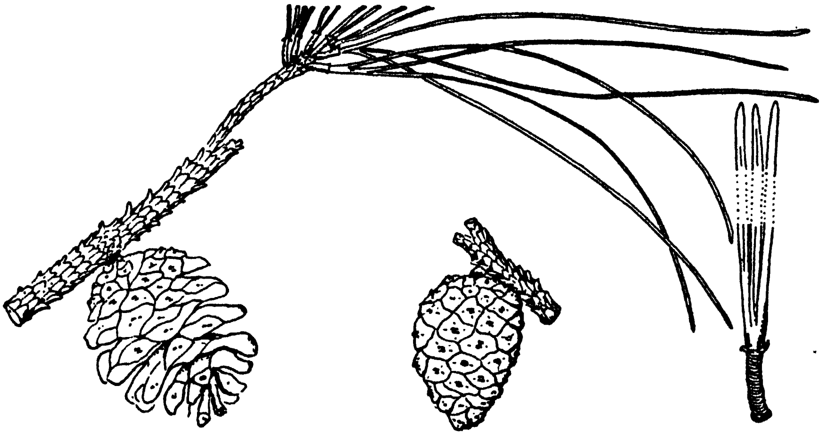


Figure 26.—**Pinus insularis** Endl. (Benguet Pine). Stated to have been exploited in the Philippines in Spanish times as a source of rosin or turpentine (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by West and Brown).

Production in Central American Countries:—Throughout central America pine trees occur frequently in the mountainous regions and at the higher altitudes. In some instances, particularly in Mexico, they have been tapped for resin. In addition to those of Mexico, pine forests occur in parts of Guatemala, Honduras, British Honduras, and Nicaragua. They also occur, but less freely in Salvador and northern Costa Rica. At the higher altitudes of some of the larger West Indian islands, Cuba and the Dominican Republic, they are also to be found. In these countries the low lying tropical belts and the coastal areas support hardwoods or broadleaved trees while the pines are restricted to the higher altitudes or the subtropical belts. These are invariably the more inaccessible regions and this accounts for the comparatively little attention that has been paid to these pine forests, either for timber or for resin.

Mexico is the most important resin producing country in central America and has extensive pine forests. These are mainly located between 4000 and 15,000 feet. Some two dozen different species of *Pinus* occur in Mexico (P. C. STANDLEY 1922), many of them exceedingly resinous. Some are the same species that are to be found in the southern United States.

Among the Mexican pines considered suitable for resin production are—*Pinus caribaea, P. ponderosa, P. arizonica, P. teocote, P. chihuahuana, P. montezumae,* and *P. ayacahuite* (M. MARTINEZ 1945). Formerly much crude and wasteful exploitation took place and boxing was the common practice. Later laws were drawn up designed to prevent wasteful exploitation. These prohibit boxing in favour of the cup and lip method. No trees under 12 inches diameter may be cupped, not more than two cups hung on a single tree and 5 inch bark bars preserved. Much of the rosin and turpentine produced in Mexico has come on the markets of the western United States and a good deal is consumed in Mexico in soap and other industries (U. S. Naval Stores Handbook: M. MARTINEZ 1945).

The exploitation of pines for turpentine and rosin has taken place to a limited extent in Honduras and in Santo Domingo and concessions held there. However the previous unsettled status of land ownership and unstable conditions of government in the latter country rendered exploitation as a business enterprise difficult.

Chapter X

DAMMARS

The word "damar" is a Malay word used in Malaya and the Malay Peninsula for any kind of resin or for a torch made of resin. The name has come to be used in commerce (generally spelled "dammar") for the resins of these regions. These are derived from trees belonging to the family *Dipterocarpaceae,* several different genera being concerned. Modern industry is not interested in these materials as illuminants but as a raw material for varnishes and kindred substances. The name "diptodammars" has been suggested by TSCHIRCH for these resins, but it has not been generally adopted. The word "damar" came into use as an English word when the first British traders visited Malaysia, for the product was easy to obtain in the ports. From its being washed down the rivers to the sea one writer in 1673 spoke of it as being "taken out of the sea." In those days dammar in small quantity was also obtainable from India and Ceylon (BURKILL).

As a group, the dammars are characterized by their free solubility in turpentine and coal-tar hydrocarbons which serves to distinguish them from the copals. Although inferior in hardness and durability to the copals they are of special value in the manufacture of so-called "spirit varnishes" owing to their pale colour and good solubility. In general it is only the better grades of dammar, those of light colour and reasonably free of impurities, that are now used in industry. The pale grades are made into crystal white paper varnishes and white enamels. They are commonly used for wall papers and indoor decorative work. They are also used to improve the lustre and adherent powers of the nitro-cellulose film of cellulose lacquers. Paleness, hardness and transparency are regarded as the three cardinal virtues of good dammar. The poorer or dark grades of dammar have been used in cheaper preparations such as paint for ships' bottoms.

The family *Dipterocarpaceae* is a tree family of very great importance in the Indo-Malayan and East Indian regions. It includes a large number of important timber trees and most species yield resin in greater or less amount. The characteristic feature of the family is the fruit which often resembles a shuttlecock with two to five vanes. Flowering and fruiting is seasonal, but many kinds flower only at intervals of several years and then for only a short time. It is this sporadic flowering combined with the height or inaccessibility of the flowering branches that has been the cause of the uncertainty of their botanical identity.

East Indies:—The age-long use of dammars among the peoples of Malaysia has been for illuminating purposes in the form of torches. They are also used to some extent for caulking boats, for medicinal purposes (ointments) and in batik work. In making torches the powdered dammar is usually mixed with other materials such as decaying wood, bark chips and wood oil, and wrapped in palm or other large Monocotyledonous leaves in cylindrical or tapering form two feet or so in length, the whole being then often bound round with split rattan canes to give rigidity. In Java split bamboo may be used to hold the powdered resin, or the resin may be heated in an iron receptacle until plastic and then rolled into cylindrical rods on a board (HEYNE). For indoor illumination, these resin torches or resin candles as they may be more appropriately called, have largely been superceded by the more efficient and less smoky kerosene or paraffin lamp, but they are stated to be still in use in the more remote parts of Borneo and Sumatra. The torches are prone to smoke and require frequent attention if a column of thick black smoke is to be avoided. The interior of the dwellings where such torches are used are commonly much blackened by soot. Some varieties of dammar burn better than others as torches. Many of the dark dammars, for which there is now little or no demand commercially, are well suited for torches. The torches are used as lanterns out-of-doors for driving bullock carts by night, etc., and for fishing. They may also be employed as fire lighters for which they are well suited in a damp climate.

The best forms of dammar to reach oversea markets are those known in the countries of origin as "damar mata kuching" (cat's eye dammar), and "damar pĕnak." The trade recognizes several grades of dammar of the "mata kuching" type. The most esteemed is "Batavian dammar," the finest grade of which is in the form of large very pale coloured lumps. The superiority of Batavian dammar is stated (HEYNE) to be due to the very great care with which it is sorted and graded. This resin forms solutions in coal-tar hydrocarbons that are almost water white and very stable. Batavian dammar consists mainly of resins from western Java and eastern Sumatra, Batavia being the important collecting and exporting centre. A certain amount of dammar from Borneo has also found its way to Batavia for export in the past. Resins from central Sumatra are mainly exported from Pedang on the south coast of the island. "Pedang dammar" is usually a clear, pale yellow colour and in smaller fragments than the best Batavian. In the past a good deal of dammar has been exported from Pontianak in Dutch Borneo—believed to be largely obtained from species of *Shorea.* Some grades are good, others inferior, owing to small size and contamination with fragments of bark or wood. Borneo dammar is mostly obtained by tapping, but a certain amount is from naturual exudation on the branches and trunks and is obtained by climbing. "Singapore dammar" is a trade term for dammar shipped from Singapore, most of which originates from neighbouring islands and not from Malaya itself.

The botanical origin of the "damar mata kuching" that is imported is often quite obscure and varies with different districts. It is, however, believed that the trees yielding this resin belong mainly to a group of small leaved Hopeas, among which are:—*Hopea dryobalanoides, H. globosa, H. griffithii, H. intermedia, H. mengarawan, H. micrantha* and *H. myrtifolia.* In the Moluccas *Shorea koordersii* is believed to be a source (HEYNE), and in Malaya *Shorea bracteolata* and *S. crassifolia* (BURKILL).

The Dutch East Indies are important sources of copal, *i.e.* "Manila copal" from *Agathis alba,* as well as dammars. To the natives all are "damar", the term copal (of Mexican origin) being quite unknown to them. Although the two resins differ markedly in chemical properties and solubility in different solvents, it is not always easy to distinguish the two by the eye, except in the case of the better grades. A certain amount of mixing or adulteration is therefore liable to take place.

Malaya:—The Malayan forest vegetation is very heterogeneous and extremely rich in the number of different tree species it contains. These probably exceed 3,000. In spite of the prevalence of resin yielding trees of the family *Dipterocarpaceae* in the forests of Malaya that country's contributions of dammar to world markets in the past have not been large. This may have been due in part at least, to the high level of prosperity the country has enjoyed in the present century, due largely to the rubber and tin industries and the fact that there may not have been the same incentive for the strenuous or even dangerous work of resin collecting in order to obtain money as has existed in other parts of Malaysia and the East Indies.

Until the supervision of dammar collection by the Forestry Department in Malaya in 1922, the dammar imported was on the whole of poor quality owing to the mixing of the better dammar ("damar pěnak") with poor quality resin by merchants and shippers to increase the bulk. Furthermore, much injury was done to trees through bad tapping methods—too much tapping at the base of the trunk—and sometimes trees were even felled to obtain resin adhering to the branches or upper part of the trunk. The Forestry Department encouraged the collection of "damar pěnak", undertook its purchase from the collectors, paying a fair price, and its grading, export and marketing, all with very gratifying results. Exports of this resin rose considerably for several years but were later affected by world economic conditions and competition with synthetic resins.

Damar pěnak.—This resin is yielded by one of the well known trees of Mayala, *Balanocarpus heimii,* known also as "chengal" or "chengai." It is considered to be the fourteenth most abundant tree in Malaya and is one of the chief timber trees, reaching very large dimensions. It occurs scattered in the forest and not gregariously. The tree is slow growing and it is thought that an age of about 50 years is necessary before it reaches a suitable size for tapping. Trees up to 40 feet in girth and probably over 1,000 years old are found. In climbing the trees, adjoining smaller trees or climbers may be used, or a sling employed if the bole is of suitable size. Very often, however, a form of ladder is attached to the tree by inserting bamboo or hardwood pegs or spikes into the trunk one above the other and tying a rattan cane or sapling to them so that it is supported parallel to and a few inches from the trunk. The making of these ladders requires a good deal of skill. The pegs are only driven into the sapwood. If driven too far, *i.e.* into the heartwood, they are liable to spring or loosen. By these means the upper part of the bole, said to produce the best resin, may be reached for tapping. With whatever method is used the collector makes a number of incisions at intervals up the trunk. From these the fluid resin flows and gradually hardens, usually in stalactytic rather than the globular form—characteristic of "damar mata kuching". It is collected after about three months when the wound is freshened up to induce a further flow. Collecting may be done at intervals of three or four months. The tapping is without apparent damage to the tree if the work is carefully done. The cuts should not be deep or rough. A deep cut may damage the tree and a rough one leads to woody or other impurities in the resin. Under the Government controlled tapping in Negri Sembilan, trees were allocated to collectors, about thirty per man, which he would tap as a spare or part-time job "whenever he has a free day or can sum up sufficient energy." Owing to the death of a certain number of the tapped trees it is thought tapping might well be limited to such trees as are due to be felled within ten years. (J. C. K. Marshall 1934). The best or most suitable taps or cuts are considered to be about four inches high by four inches wide penetrating half an inch into the wood. These may be made either on the bole or on the larger branches. The resin, when it first forms, is intensely sticky and if collected before it completely hardens, in less than about three months, is liable to spoil any good dammar with which it comes in contact.

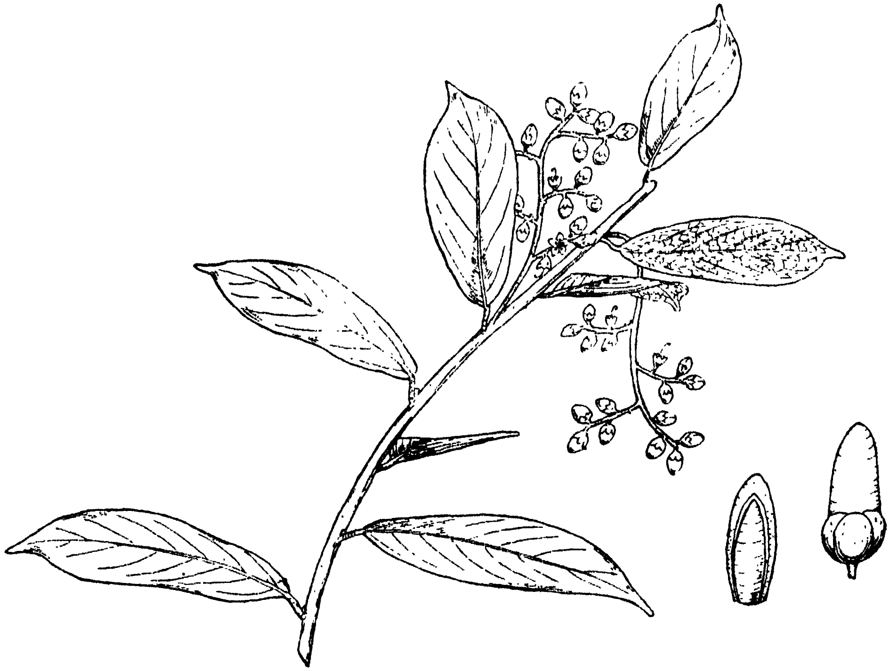


Figure 27.—**Balanocarpus heimii** King. The source of "damar pĕnak", one of the best Malayan dammars.

Under the Government scheme the collectors brought their dammar to the various purchasing stations where the impure, imperfectly hardened or dead dammar was picked out, after which it was sent to a central depot for sorting and grading. The first operation consisted of resifting the lump and the dust. The dust was separated into three grades—"fine dust," "seed" and "nibbles." Bark and other impurities in the "nibbles" were removed by a flotation process. The lumps were first graded for size and then handpicked by women for colour into "pale," "yellow" and "amber," the smaller sizes being graded into "pale" and "yellow" only. "Dead dammar" and dirty pieces were kept separate and sold as "dammar coarse" and floor sweepings as "fine dust 2nd grade."

The grades of "dammar pĕnak" sold under the Government method of grading were therefore "pale," "yellow," "amber," "seed," "fine dust," "coarse" and "fine dust 2nd class." Boxes made locally and paper lined were used for all grades, bar the "coarse," which was bagged. This Malayan "dammar pĕnak" came to be known in the resin trade as "M.D.P." The resin deteriorates somewhat on prolonged storage (over a year), whether exposed to sunlight or kept in the dark. The acid content increases and the colour becomes darker. As the market price of dammars deteriorated in the early 1930's with the world depression, it was found the only grades that produced a profit were the "pale" and the "yellow." In 1925, tappers could earn 40 straits dollars a month, whereas nine years later 10-12 was the maximum.

The so-called "dead dammar" is a white opaque form of "damar pĕnak" which sometimes exudes from trees, especially young ones. The causes of its formation are not well understood, but the opacity is believed to be due to water. This dammar is disliked by the varnish maker as it gives cloudy solutions, although in varnish trials it appeared to be hardly inferior to the clear form of the resin. The resin deteriorates somewhat on prolonged storage.

Other Malayan dammars.—Numerous other less valuable dammars are produced in Malaya, a good account of which has been given by BUCKLEY. The names used for these dammars by the Malays are general ones and indicative of the colour or appearance of the resin. It is rarely that the names can be correlated with any certainty with the resins from any particular botanical source.

"Damar hitam" signifying "black resin" is used for almost any very dark coloured resin. Much of the "damar hitam" that has been exported from Singapore in the past has been resin imported from elsewhere and not obtained in Malaya. *Balanocarpus penangianus* is one of the sources of Malayan "damar hitam."

"Damar daging" (daging-flesh) is a reddish coloured resin of attractive appearance that sometimes reaches the markets. It may be of a pure dark red colour, or have whitish layers or streaks giving the appearance of meat. Frequently it is collected from the ground.

"Damar seraya" (*Shorea curtisii*) is a hard reddish brown resin with a laminated vitreous fracture.

"Damar batu" (batu-stone) is a name used for almost any opaque dammar. Most of it is collected from the ground, from water courses, or the hollows of trees. None is obtained by tapping.

"Damar kepong" is an opaque, soft, yellow resin often streaked and usually in stalactytic form, yielded by species of *Shorea*, including *S. rigida* and *S. sericea.*

"Damar temak" from *Shorea hypochra* is a pale resin very like "damar pĕnak."

"Damar chengal pasir (*Hopea* sp.) is not unlike "damar mata kuching."

"Damar sengai" (*Canarium* spp.) is a very dark resin.

"Damar kedondong" is a soft resin of the elemi type, also derived from species of *Canarium.*

"Damar meranti" is a name used for various resins originating from different species of *Shorea.*

"Damar kĕlulut" and "damar siput" are two interesting resins in that they are collected through insect agency. The former is the lining of the peculiar nest of small bees (*Melipora* spp.) that collect the resin from trees in the neighbourhood and use it mixed with wax. The resin may be of a mixed nature and consist even of fragrant resin. "Damar siput" (siput = shell) occurs as hollow shell-like exudations on the trunks of certain trees (*Shorea* spp.), and is believed to be formed by larvæ of a coleopterous insect that live in the bark (BURKILL).

Siam:—Dammar is used locally by the inhabitants of Siam in the same manner as in Malaya, for torches and as an illuminant. It has been exploited to some extent in southern Siam for export, the product finding its way to Singapore and being exported as Singapore dammar. This dammar from Peninsular Siam is stated to be very similar to the better grades of Malayan "damar mata kuching" and "damar pĕnak." It is derived from similar botanical sources as Malayan "damar pĕnak," *i.e. Balanocarpus heimii* and *B. maximus,* both large forest trees occurring on the slopes of mountain ranges in southern Siam. The trees are particularly common in the circle of Pattani where they are tapped for dammar. The trees are also exploited for their timber which is much prized for furniture and building purposes.

Tapping for dammar has to some extent been controlled and regulated by the State Forestry authorities. This has only been done in certain areas. In some districts tapping is not permitted. In others permits are issued on payment of a fee. The minimum tappable size for trees is 200 cms. girth at 75 cms. from the ground. The taps or holes must not exceed 10 cms. in length and 5 cms. in depth with a distance of not less than 30 cms. between them. They may extend right up the bole of the tree to the crown. As in Malaya three to four months is considered the necessary period for the dammar to become thoroughly dry. Sometimes it is collected sooner owing to the danger of theft, but this results in an inferior dammar. After each collection the tapper freshens up the cuts to encourage a further flow. When exudation ceases, new cuts are made and the old ones left to heal over.

Each tapper usually carries a bamboo basket tied to his waist to receive the resin, and may tap two to three large trees in a day, working from early morning till midday. The average annual yield of dammar per tree is about 1/3 picul or approximately 45 lbs. ("The Forests of Siam," compiled by the Royal Forest Department). Chinese middlemen purchase the dammar after which it finds its way to Singapore to be graded and sorted before export.

Other trees yielding resin (for local use) in Siam are species of *Shorea*. notably *S. obtusa, Pentacme siamensis* and *Hopea odorata.* The trees are not tapped, the resin being collected as a natural exudation.

India, Burma and Ceylon:—The family *Dipterocarpaceae* is well represented in the forests of India, Ceylon and Burma, and includes many of the important timber trees of those countries. In some instances the trees yield resin or dammar copiously and this is collected for local use. Some of these dammars, such as Indian "black dammar" and "white dammar" have on occasion been exported to European countries in the past, but only in small quantities and at irregular intervals.

One of the best known of the Indian Dipterocarp resins is perhaps that of the "sal" tree (*Shorea robusta*) commonly called "lal dhuna". This tree is extremely common in many parts of central and northern India where is is often the dominating tree in the forests and of very great importance for timber. The resin generally occurs in stalactitic form, is of a pale creamy yellow colour, nearly opaque, and somewhat aromatic. It is used locally for caulking boats and for incense. In the Darjeeling district large pieces of resin, 30-40 cubic inches in size, are sometimes dug up from beneath the trees. Much injury has been done to the trees in the past by excessive tapping (GAMBLE). A closely related species, *Shorea tumbuggaia,* of more restricted distribution but common in the Cuddapah forests, also yields resin.

Indian "white dammar" or "Piney resin" is obtained from *Vateria indica,* a large evergreen tree of the forests of western peninsular India. It is met with in lumps of all shapes, generally bright orange to dull yellow, but sometimes greenish in colour. It is very hard when thoroughly dry, with a shining vitreous fracture and resembles amber. Its superior hardness, colour and amber-like appearance is said to distinguish it from other Indian resins. In India it has been used for home made varnish, being readily soluble in turpentine. Mixed with coconut oil it is also used for torches or "candles." *Vatica roxburghiana* and *V. lanceaefolia* are allied Indian species yielding resin.

The so-called "black dammar" of India is not a Dipterocarp resin, being obtained from *Canarium strictum* (*Burseraceae*) and possibly other species of *Canarium.* This dammar has a bright shining black appearance when adhering to the tree, but if held between the eye and the light is transparent and of a deep brownish colour. The common method of obtaining the resin is to make vertical gashes round the base of the trunk and to make a fire with brushwood against it. The resin will exude for many months. It is soluble in turpentine and has been used locally for varnish and for other purposes. *Canarium strictum* is a large deciduous tree in evergreen forests up to 5,000 feet on the west coast of India, and is conspicuous when coming into leaf as the young leaves are crimson.

Some of the trees yielding resins in India also occur in Burma. The large evergreen forest tree *Hopea odorata* ("thingan") yields a resin which is yellow or straw coloured or almost colourless and in nodules about the size of a walnut. This resin is soluble in turpentine. In the powdered form it may be used as a styptic by the Burmese. On account of its hardness it has been referred to as "rock dammar." *Shorea obtusa,* which occurs in the "Eng" forests of Burma, also yields a light coloured resin. Many of the Dipterocarps of Burma, especially in the genus *Dipterocarpus,* are tapped for the oil or oleo-resin they contain, which remains in a liquid state and does not solidify as do the true resins (*see* page 158).

As in India and Burma, dammars or dammar-like resins have not been systematically collected or exploited in Ceylon for oversea markets, in spite of the presence of numerous *Dipterocarps* in the native forest. A good quality light coloured dammar or resin is known to be yielded by *Doona zeylanica* and *D. cordifolia,* but neither trees are now abundant in the island. The former takes its Cingalese name "dun" from the copious resin it affords. This often collects in masses on the trunk and lower sides of the branches. *Vateria acuminata* ("hal") is a stately endemic tree of Ceylon which produces a pale, sometimes greenish transparent resin ("hal dummala") said to be well suited for varnish (F. Lewis 1934). It has been used in Cingalese superstitious ceremonies.

Chapter XI

KAURI RESIN

The History of the Industry in New Zealand:—Kauri resin, commonly known as "Kauri gum" (pronounced cowrie) and sometimes as Kauri copal, is one of the most valuable of the hard natural resins. It is obtained mainly in the fossilized or semi-fossilized form from the earth on the sites of present or former kauri forests, being derived from the "Kauri pine," New Zealand's largest and perhaps best known tree.

The history of the kauri resin industry is of interest, the first mention of the resin being in Capt. COOK's diary for 16th Nov. 1769. A good account of the vicissitudes the industry has been through and of the various methods employed at different times for obtaining the "gum" has been given by J. L. HARRISON SMITH (1940-41). According to this writer "Kauri gum" has been an important article of commerce in New Zealand's exports since about 1847 and up to the end of 1939, 442,501 tons, valued at £23,730,163 had been exported. The peak year was 1899 when 11,116 tons were exported. In the following year the export was slightly less but the value was £662,293, the highest recorded. The record low level since 1865 was in 1932 when 2,068 tons were exported, valued at £62,137. The average price per ton has varied considerably *e.g.* £10 in 1860, £36 in 1888, £51 in 1900, £84 in 1920 and £48 in 1939. The bulk of the exports have gone to the United Kingdom, but the United States has also imported large quantities. The 1939 figures were as follows:—United Kingdom 1,405 tons: U.S.A. 405: Canada 208: Holland 77: Australia 73: France 70: Japan 31: Germany 26: Sweden 21.

The Kauri Pine and its Distribution:—The kauri (*Agathis australis*) is the monarch of the New Zealand forests, dwarfing in stature and magnificence the other trees. With its tall cylindrical bole, almost without taper, it ranks among the largest timber producing species in the world.

For over a century the timber has figured prominently in the international wood trade of the world, yielding flawless timber of exceptionally large size. With the depletion of the original forests of the early settlers the supplies of this valuable timber have grown less and less. The largest trees recorded reached 150-200 feet in height and nearly 30 feet in diameter but the average run of trees is very much smaller. Trees may reach a great age—2,000 years or more. As the tree grows it casts its lower branches while those of the crown in veteran trees may be three feet in diameter. The leaves are glossy olive green but the trees are sparsely foliaged. The bark is ash-gray in colour and thin for the size of the tree. It seldom reaches ½-1½ inches in thickness and its structure is characterized by a multiplicity of resin cells, the ultimate source of the commercial resin. In mature trees the bark scales off in flakes, sometimes several square feet in size. These may form a decaying heap at the base of the tree several feet thick. The scaling of the bark keeps the tree free from epiphytes so characteristic of the other forest trees. The cones, which are spherical and 2-3 inches in diameter, take about 18 months to ripen and break up on the tree. Good seed years are infrequent.

The kauri occurs only in the north of New Zealand, in the north of North Island and not south of 38°S latitude. "Though only scattered in the North Cape district, it occurs very generally throughout the North Auckland Peninsula, on the Waitakerei Ranges outside Auckland City, on the Coromandel Peninsula as far south as Te Aroha Mountain, and on the hilly country lying between the Firth of Thames and the Main Trunk Railway. A few relics remain between the Waikato River and Raglan Harbour and to the south-south-west of Tauranga, the southernmost trees being recorded in the vicinity of Kawhia Harbour on the west and from Mamaku Plateau, about twenty-five miles south-south-west of Tauranga, on the east" (A. R. ENTRICAN 1935). The tree is essentially a lowland species and seldom occurs above 1600 feet. It occurs on a variety of soils ranging from rich, wet bottom lands to barren rocky hillsides but is usually found on the poorer soils, being replaced by other trees on the more fertile ones. At the times of the European occupation of New Zealand there were many hundreds of thousands of acres of kauri but now only some 35,000 acres of dense virgin kauri forest remain. There are in addition many thousands of acres of mixed kauri podocarp forests and cut over lands with young trees.

Collection of the Resin:—The collection and marketing of kauri 'gum' in New Zealand has been under Government supervision for many years, the first important act being the Kauri Gum Industry Act of 1898. Gum diggers', gum buyers' and brokers' licenses are issued by the Crown. Most of the gum collected is dug up from the earth but a certain amount is collected from the trees—the result of natural exudation. Pieces of two to four pounds weight are the usual size but lumps of 50 lbs. have been obtained from branches. The resin obtained from trees in this way is generally termed "green gum". At one time trees were climbed by throwing a line with a rope attached over one of the main branches and then descending gradually by means of a bo'sun's chair and collecting the resin. Later, about 1920, climbing irons and climbing boots came into use to ascend the trees (HARRISON SMITH), the bo'sun's chair being used as before in descending and the gum chipped off with a small axe into a canvas bag carried round the waist. Great physical fitness is called for in this work, which may be both arduous and dangerous.

In the past a good deal of resin has been obtained by tapping the trees or "bleeding" as it is termed, but this is now for the most part prohibited. If the cuts do not penetrate the wood and are not too numerous little harm seems to be done to the tree, the tree's habit of shedding the bark obliterating the wound in time. "Candle gum" is a term sometimes applied to the freshly exuded resin.

The collection of the resin or fossil gum from the earth may be divided into several phases for widely different methods have been employed in the last 100 years. At first the rich "gum" bearing land was simply dug over one spit deep with a spade as in digging a garden and the larger pieces of "gum" picked out. This was usually in the drier and hilly districts and not the swampy areas This method of digging came to be known as "paddocking" and the product as "range gum", in contrast to "swamp gum". In later years, as the range gum became less easily obtained, ground was redug and dug a second spit or even deeper. A piece of wire with a wooden handle, termed a "nappi-nap" was also used to probe the ground and locate pieces of gum. This was the forerunner of the specially made steel gum-spear, greatly improved in 1910 by the invention of the "joker", a piece of wire bound round about an inch from the point which considerably reduces friction of the rest of the spear in the soil by the larger hole it makes. This enables the spear to be used at much greater depths, even 15-20 feet. With shallow or range gum becoming scarce more attention was given to swamp gum. Here different problems arose, such as the need for baling out water from the pits, etc., and payable methods for recovering the gum present in the soil as small or granular fragments. Mechanical devices operated by hand were devised for separating the "gum", along with other vegetable debris, from the mixture of swamp earth and water fed to it. Later power operated outfits of considerable complexity came into being, "gum" bearing ground being systematically worked strip by strip.

Various methods, wet and dry, are used to separate the "gum" fragments from the other matter such as pieces of root, etc. that collect with it. Differential flotation with brine or clay may be used as well as mechanical winnowers after drying.

In the early days of gum-digging in New Zealand when the production of range gum was at its peak several thousand men made their living as gum diggers. Large pieces of gum, even up to 100 pounds in weight were sometimes located while pieces the size of a man's head were common. Later the number of diggers declined. It was for the most part the unsettled roving members of the community who took to the work—being of much the same stamp as an average colony of gold diggers we are told, or as one writer put it "Bohemians of every nation—European, American, Australian, all find their way to the gum fields". The work was laborious and dirty and the digger on his return to camp after the day's work often looked like a stoker coming off his shift.

Waste kauri wood has been considered as a source of paper pulp and resin. Resin has also been obtained by solvent extraction from the stumps and remains of trees on old kauri forests down to a depth of 30 feet (HEDLEY BARRY).

Grading and Marketing:—A boom period for kauri resin took place about 1921. The "range gum" or "white gum" as it was called was in three grades—(a) "Clear" (clean and free from dirt), (b) "R.S.W." (rescraped white) and (c) "O.W." (ordinary white). Later the premium on scraped gum fell and intensive hand scraping was dispensed with. Scrapings and chips were sold separately.

Swamp gum, being generally dark, is usually referred to as "black gum", the common grades being—(a) "Pale Select," (b) "R.S.B." (rescraped black), (c) "S.B." (Steel Black), (d) "B.1" (half sugar, half solid gum) and (e) "B.2" (sugar). "Sugar" is a sugar-like type of gum often forming a large part of the diggings.

During the boom period the best grades of swamp gum ("Pale Select") sold for about £115 a ton while "B.1" and "B.2" stood at £36.

Prior to the Second World War London prices for New Zealand kauri resin were—"pale chips" 100/-, "brown chips" 50/- and dust 15/- per cwt.

Main Uses:—For a long period and before the advent of synthetic resins, Kauri resin held a premier position in the varnish trade, the better grades producing very high quality varnish of good durability, very elastic and with little or no tendency to "bloom." From the varnish maker's point of view the resin is easy to "run" and to combine with oil. The lower grades of the commercial resin, containing a fair percentage of impurity, are much used in the manufacture of linoleum. Its use for this purpose became general some thirty years ago and provided a good outlet for the poorer grades not well suited for varnish making. For nitrocellulose paints and lacquers kauri resin is not so well suited as some of the natural resins, being less readily soluble in the usual solvents.

Chapter XII

LAC RESIN AND SHELLAC

Lac, familiarly known as shellac in its refined, flake form, owes its origin to insect secretion and is therefore not a vegetable resin in the true sense. However, the facts that the resin is always formed on plants, that plant sap is the sole source of food of the insect concerned, and that the resin has many points of similarity with vegetable resins may be considered as justification for including it among plant resins. Furthermore, the whole question of lac production is bound up with many interesting botanical problems in connection with the host plants and their interrelationships with the lac insect.

The Lac Insect:—Both a resin and a red or crimson dye are derived from the lac insect. It was only in the last century that the resin began to be extensively used and exported. Before that it was the dye that was sought after, having been used throughout the ages in India and referred to in Sanskrit writings. At one time an important export trade in the dye to European countries existed. The discovery and production of cheap aniline dyes that proved superior to it caused export to cease and it fell into disuse. In parts of India it is still used to some extent to dye silk and for other purposes. Its name however remains familiar in the form of the "crimson lake" of the paint box. The lac insect, *Laccifer* (*Tachardia*) *lacca* belongs to the family *Coccidae* (plant lice) which includes the cochineal insect and numerous serious pests of cultivated plants. The lac insect is the most valuable member of the group to man. Many of its allies also yield resin, but as they live in a scattered fashion instead of close together in colonies, as does the lac insect, it is not practicable to collect their secretion.

The life history of the lac insect has been studied in detail and is well known. The vital act of swarming—the time for increase—normally takes place twice a year, usually in July (in northern India) and in December or January. When this occurs, the larvæ emerge as small, pale, crimson specks (about ½ mm. long) from the dead shell of the mother and immediately commence to walk about in search of a suitable feeding place, such as a young branch. Here they anchor themselves, the females for life and the males until maturity, and commence feeding. Through their habit of fixing themselves close together on the branch, the varnish-like secretion of the individual larvæ becomes a continuous coat beneath which the further development and the metamorphosis of the insects takes place. After a month or more of growth the male insects are mature and emerge, winged or unwinged, to seek the females. When fertilization has taken place the females commence to feed voraciously and increase their resin secretion. They live for another two or three months then produce eggs and die, a shrivelled dark crimson or blackish skin only remaining after the hatching of the brood.

When newly emerged, the larvæ cannot move more than a distance of about 12 feet and if unable to find a feeding place on the first day probably die. It is believed that in the natural state high winds may blow them from tree to tree and that they may even be carried and distributed on the legs of birds. In lac producing districts brood lac is transferred by hand from one tree to another. Different races or strains of the lac insect are distinguished and the use of a suitable strain in any particular district or with any particular host plant may be of practical importance to the lac cultivator (P. M. Glover, 1937).

Host Plants and Cultivation:—The lac insect may occur on a large number of different host plants, probably about a hundred being recorded, but only a small proportion of these are important in the actual commercial production of lac. Those of major importance in India are:—*Schleichera oleosa* (syn. *S. trijuga* ("kusum")), *Butea monosperma* (syn. *B. frondosa* ("palas")), *Zizyphus jujuba* ("ber") and *Acacia catechu* ("khair"). Other species well known as host plants either in India or Indo-China are several species of *Ficus* and *Dalbergia, Cajanus indicus* ("arhar"), *Albizzia lucida, Combretum quadrangulare, Ougeinia dalbergioides, Acacia arabica* and *A. moniliformis, Grewia multiflora, Leea robusta, Berrya cordifolia* (syn. *B. ammonilla*) and *Engelhardtia spicata*. A detailed list of Indian trees on which lac will grow has been given by Stebbing (1910), but the majority are of no commercial interest.

A few species, *e.g. Zizyphus xylopyra* ("ghont"), are of value in restricted areas only. Some species are good host plants in some districts but of little or no value in others where climatic conditions are different.

It will be noted from the above mentioned species that the lac insect is not confined to a single genus, nor to a single family or even to a group of closely related families as are many insects. Furthermore, frequently one or more species in a genus may be lac hosts but the other members of the genus are not. What is it that determines whether the lac insect will live on any given species or not? It is now believed that the sap reaction and sap density are important factors in this connection (Glover). In general the sap reactions of good lac hosts have been found to approach neutrality (*e.g.* pH 5.8-6.0), those of non-lac hosts showing greater acidity or alkalinity. The sap density of good lac host plants has been found to be much lower than that of a number of non-lac hosts. It would seem, therefore, that trees in the American and African tropics, on which lac has not yet been tried, may ultimately be found to possess suitable sap reaction and sap density and prove to be satisfactory lac hosts where climatic conditions are suitable.

With lac host plants in India it is common to find forms or biological races of the species occurring in the same area, the one a good host-plant and the other a non-host. Usually such plants appear to be similar morphologically or indistinguishable, although the "raiyot" or peasant cultivator is able to distinguish between them by some subtle difference such as the colour of the inner bark or small differences in the leaves and has his own names for them. Good examples are given by Glover (1937).

The differences in the quality of the lac from different host plants is usually slight, but "kusum" (*Schleichera oleosa*) is generally conceded to give the best quality lac in India. This tree grows to a large size, although slow growing, and has other economic uses for it yields a valuable timber, an edible fruit and an oil yielding seed. "Khair" (*Acacia catechu*) is another host plant of general economic value, being a source of tanning material and a useful timber, but other important lac hosts are trees that are otherwise of no special economic importance. In those parts of India where the heat of the sun is intense at certain seasons the amount of shade afforded by the leaves in the case of different host plants may be important in determining to what extent the lac insect is able to thrive. A suitable host plant in one area may be unsuitable in a hotter district on this account.

The lac insect thrives best under what might be termed orchard or plantation conditions rather than in typical jungle. Most of the lac of commerce is collected by peasant cultivators who have a few host trees on their holdings, such as at the margins of fields or on waste or grazing land. Collection and cultivation of lac is subsidiary to other activities and regarded as a side line, with a tendency to being neglected in times of prosperity. The cultivation of lac in specially laid out plantations has not so far been carried out in India, except at experiment stations, and is not regarded as an economic proposition, especially with the wide fluctuation in price that has always been a feature of the Indian lac trade.

For the lac insect to be successfully established on a host plant it is essential that a sufficient number of young branches with soft tender bark be present, for the mouth parts cannot penetrate old or hardened bark. One of the first operations in successful lac cultivation therefore, is the correct pruning of the tree at the correct time. Much experimental work on this, as on other aspects of lac cultivation, has been carried out at the Indian Lac Research Institute, Namkum, Ranchi, Bihar. The best methods and the best times for pruning vary with different host plants and in different districts. When one lac crop follows another on the same tree the collection of the lac in itself evolves a form of pruning, which may be sufficient to stimulate the needed amount of new growth for the next crop. Except in the case of very young trees some form of pruning is always necessary to ensure a good crop.

The artificial infection or inoculation of fresh host plants is a simple matter. Sticks of brood lac, emerging or on the point of emerging, are either tied to the young branches or near them, or simply interwoven among the young branches. Short pieces may be placed in a bamboo basket which is tied to the young branches. The average cultivator is able to forecast with fair accuracy when the brood will emerge or swarming take place from the general appearance of the incrustation. Healthy brood lac only should be used for inoculation, the lac insect being liable to attack by a number of insect enemies.

Collection and Preparation of Lac:—The collection of lac in India may be undertaken at almost any time, but usually from June to July for the "baisakhi" or summer crop and October to November for the "katki" or winter crop. It does not deteriorate if left on the tree for a time, but from the cultivator's point of view there is often danger of loss from theft. The practice of removing the resin encrusted twigs before the insects have swarmed is bad in that large numbers of young insects perish and the lac contains the maximum quantity of dye which has to be washed out in the preparation of the resin. Such immature lac is very moist, difficult to dry, "blocks" easily on storage and in general constitutes a low grade product. After the lac encrusted branches are cut from the tree they are cut into convenient lengths, dried, and in due course sold or taken to the factory.

Most of the seed lac and shellac produced in India is the product of small factories and details of preparation vary somewhat in different localities. The first process is the removal of the resin from the sticks or branches. This may be done either by scraping with a knife, beating with a mallet, or by means of a mill with crushing rollers, hand or power operated. Three products are obtained—the granular resin ("seed" or "grain" lac), resin dust and waste, and the deresinated twigs (used as fuel). The seed lac is then washed to remove the red dye and may be either exported as such or made into shellac or button lac.

Shellac may be manufactured from seed lac or grain lac either by the original Indian or country method, a rather involved process requiring much hand labour and skill, or by modern factory methods which include solvent extraction processes using alcohol and steam heating or pressing processes, details of which are largely trade secrets. It is thought that about 75% of the shellac produced is manufactured by the "country" method. In this the seed lac is placed in a long narrow cloth bag, about 30 feet long and 2 inches in diameter; which is then gradually passed in front of an open fire and worked or twisted, causing the shellac to melt and ooze out. When sufficient molten lac has collected it is worked up with a large iron spatula (to prevent separation of the wax) and rapidly spread over a hot water cylinder or glazed earthenware pot. The resulting sheet is then removed and stretched, and when cool broken up into what constitutes the shellac flakes of commerce. For button lac the molten lac is simply dropped on to a smooth cool surface. The contents of the bags after the pure lac has filtered through consist mainly of dirt and refuse, but may still contain 50-60% shellac (extractable by solvents) and is a marketable by-product, being termed "kiri." The advantage of the "country", method is that purification is effected with a minimum amount of heating, many of the good properties of shellac being readily destroyed by heat.

Blending of different qualities of seed lac may take place before the bags are filled or rosin may be added to assist the fusion and flow of the lac. Powdered orpiment may also be added to improve colour and produce orange shellac—now considered an undesirable practice. In the case of seed lac sold or exported as such mineral acid may be used to impart brightness—also undesirable from the point of view of the user or manufacturer.

Most of the shellac made by the "country" process is of the quality or grade known as "T.N.," a term going back to the early days of the trade. A superior grade is designated "Standard I" and still better shellac as "fines" and "superfines." Shellac is sold under a large number of trade marks and descriptions (H. A. F. LINDSAY and C. M. HARLOW, 1921). Garnet lac is the term used for an inferior class of refined lac, so-called from its colour, and usually made up into thick dark coloured slabs or lumps. The dust and lac waste from factories may be used locally for making bangles and other articles.

Production and Uses:—A rough estimate of the average annual world production of lac in the years before the Second World War is 30,000 tons as against 750,000 tons as the total for natural resin production, the proportion of lac to other resins being, therefore, about 4%. India produces well over 90% of world supplies. A feature of the lac trade in the past has been the instability in prices, supplies and quality, a potent factor in restricting the industrial uses of lac and in favouring the use of synthetic resin substitutes where these are suitable.

In recent years there has been an increase in the production of seed or grain lac exported from India in relation to figures for shellac. One of the reasons for this is that bleachers of lac or shellac in Europe and America now prefer seed lac for their own requirements. For industrial and manufacturing purposes in general seed lac is in many ways superior to shellac where the possibility of adulteration or admixture with rosin and other substances is always present. The many uses of lac resin and shellac are due to a combination of properties such as its value as a moulding material and as an electrical insulator, its high resistance to the action of air combined with its ready solubility in alcohol and low melting point, rendering it easy of application. It was the discovery of its usefulness as a moulding material and electrical insulator that led to its greatly extended use last century. For a long period it reigned supreme as the basic material for the manufacture of gramophone records, about half the total output of shellac being used at one time for this purpose. With the advent of radio and decline in popularity of the gramophone the quantity used for gramophone records naturally decreased considerably. There has also been competition with synthetic resins, largely on a price basis. Properties that have rendered shellac so valuable in the manufacture of gramophone records are its being thermoplastic, hard and brilliant in finish, and with a low co-efficient of shrinkage or expansion.

Shellac has long been used both for decorative and for insulating varnishes and lacquers of various kinds. It is the main spirit varnish resin and is capable of giving a smooth finish and taking a high polish, hence its use in French polish and indoor work generally. For outside work its use is restricted as it is not completely water resistant. It is often used as a first coating on wood to fill the pores and applied (as "knotting") to seal knots likely to exude resin and disfigure or spoil finished paint work.

The so-called shellac water varnishes are simply shellac in aqueous alkaline solution, borax being the principal alkali used, although ammonia is also employed (HEDLEY BARRY). These varnishes may be used in various industries including leather dressing and finishing, in the hat trade (as a stiffening) and as wall and floor varnishes. Shellac has been largely used in the past in the manufacture of anti-fouling and anti-corrosive paints, such as are used on ships' bottoms.

In the electrical industry important uses of shellac are as a binder for mica and the preparation of insulating sealing waxes. Drawbacks of shellac from the electrical point of view are that it is softened by heat and is somewhat hygroscopic. A host of different industries consume in the aggregate a good deal of lac resin. These vary from the glazing of chocolates to the manufacture of automobile brake linings and abrasive wheels where it acts as a binder. Other uses, not yet fully developed, are in the manufacture of sound recording discs, as coatings for food containers and in bonding materials for certain types of plywood.

In recent years much research has been done on the splitting up of the lac on a commercial basis into its principal component parts *i.e.* pure lac resin, soft lac resin and wax, and on the utilization of these different products for various industrial purposes. In this connection pure lac resin is considered to be of higher value than ordinary lac as a varnish in electrical insulations, giving a film with higher breakdown voltage and water resistance, longer life with prolonged heating, coupled with excellent hardness, toughness, flexibility and adhesion to copper, with no sign of greening in contact with the metal. The softening and melting points of pure lac resin are in the neighbourhood of 84° and 95° as compared with 64° and 72° for ordinary shellac (R. BHATTACHARYA, 1938). The soft lac resin or ether soluble resin is directly soluble in drying oils such as linseed and tung and opens up new uses for lac in the baking and stoving enamel industries and in waterproofing and linoleum manufacture. Lac wax, recoverable in an exceptionally pure state, is held to be a good alternative to beeswax for many purposes and to have scope in the polishing industries. It is light yellow in colour and resembles carnauba wax in hardness and strength (A. J. GIBSON, 1935). Wax is present in natural lac to the extent of 4-7%. For some purposes, *e.g.* floor polishes, its presence is desirable, but for others (glossy lacquers) it is a drawback.

The hot spraying of shellac, which is in effect varnishing without the use of a solvent, has attracted attention in the last few years. In this process the powdered shellac is blown on to the surface to be covered but passes through a heated area just before application and so reaches the surface in the molten state. Specially designed equipment is used (The Hot Spraying of Shellac, A New Method of Coating Surfaces, London Shellac Research Bureau, Bull. No. 5, 1945). For the results of other recent work on chemical and physical properties of shellac and lac, readers are referred to the work of R. BHATTACHARYA, L. C. VERMAN, B. S. GIDVANI and others, and to the publications of the London Shellac Research Bureau.

Lac Producing Areas:—The amount of lac or shellac exported from India annually has generally been in the neighbourhood of 25,000-30,000 tons valued at approximately £2,000,000. A small percentage of this may be lac imported to Calcutta from Burma or Siam (via Singapore). For many years the United States has been the largest importer, followed by the United Kingdom.

India.—According to GLOVER (1937) lac is cultivated to a greater or less extent in Bihar, Orissa, Bengal, Assam, Bhutan, Thibet, Nepal, the United Provinces, the Punjab, Bombay, Sind, Central India, Central Provinces, Berar, Hyderabad (Deccan), Rajputana, Madras, Mysore, Kashmir and Travancore. The areas of major importance from the point of view of production are Chota Nagpur, the Feudatory States of Orissa, Central Provinces and a few adjacent areas in Bengal and the United

Provinces. About 90% of the lac of commerce is produced by them. About half the total Indian crop is produced by Chota Nagpur alone, by far the most important single area of production.

Burma.—The Federated Shan States normally produce about three quarters of the total output of lac in Burma, which is small compared with that of India proper. Lac is also produced in the Forest Circles known as the Delta, the Northern, the Central and the Chindwin. In many areas the methods adopted are very haphazard. Much is left to natural infection and lac is often cut immature with no effort to distinguish between different grades. The bulk of that exported goes to Calcutta where it is mixed with Indian grades.

Among the host plants in Burma *Schleichera oleosa, Butea monosperma,* and *Zizyphus jujuba* are important, as they are in India. Other important host plants in some areas are, *Berrya amonilla, Albizzia odoratissima, Engelhardtia spicata, Dalbergia cultrata, Annona squamosa, Albizzia lebbek,* and numerous species of *Ficus* (GLOVER).

Siam.—Stick lac is the form of lac mainly exported from Siam, for shellac is not manufactured. As in the case of Burma, export in the past has been largely to Calcutta, but in recent years there has been a tendency to export direct to consuming countries such as the United States and various European countries. Lac cultivation takes place in central and eastern Siam in the Circles of Bayab, Maharasdr, Ubon, Roi Et and Udorn, and to a small extent in Bisnuloke. Wild trees are mainly employed, the host plants being in general the same as those already indicated for India and Burma. A certain amount of cultivation of *Cajanus indicus* and *Enterolobium saman* for lac is said to take place. *Cajanus indicus* is important in the Circle of Bayab. The trees are planted about 4 metres apart and live 3-4 years, being ready for lac inoculation at 2-3 years. The yield is about 2 piculs per rai (45 lbs. per acre), but the lac is not of the best quality. Elsewhere the growers are mainly rice cultivators and may own 5-10 trees round fields, etc. In the Circle of Maharasdr, *Combretum quadrangulare* is an important host tree.

Bangkok is the important lac market in Siam and stick lac arrives there from the Provincial markets such as Chiengmai, Korat, Paknampoh, Utaradit, Denjaya and Lampang. The Chiengmai lac is regarded as the best grade of Siamese lac, being carefully collected, and that of Korat the poorest, containing much impurity and derived largely from *Combretum quadrangulare,* a tree host peculiar to Indo-China ("Lac Cultivation," Ministry of Commerce and Communications, Bangkok, Siam).

French Indo-China.—As in Siam, lac has long been collected by natives in Cambodia and other parts of French Indo-China for local use, probably throughout the ages, but it is only in more recent times that collection for export has been undertaken. Local uses for lac are in the preparation of ornamental lacquer ware, adornment of musical instruments, etc., and waterproofing or glazing domestic utensils. According to MARTIN DE FLACOURT (1927), lac is the basis of the black varnish used for blackening the teeth, a custom of some tribes both in French Indo-China and in Siam.

No attempt is made to cultivate host plants on plantation lines, the wild trees that occur in and about fields or villages and in waste places being used. The host plants include several species of *Ficus* and representatives of the families *Leguminosae* and *Combretaceae*. The main producing regions in Cambodia are in the south and are given by MARTIN DE FLACOURT as, Ponhea-Leu, Samrong Tong, Kompang Speu, Kadal Stoung, Kien Svay, Seang, Kong-Pissey, Bati, Prey Krabas, Banteay Meas, and Treang. The lac exported is mainly in the form of stick lac.

Chapter XIII

SOME LITTLE USED VARNISH RESINS

Acaroid Resin or "Gum Accroides":—This resin is the product of several species of *Xanthorrhoea* endemic in Australia and became known to Europeans almost as soon as the Continent was first visited by them. It is reputed to have been used before that time by the aboriginals in fixing spear heads to shafts, etc. The plants concerned are a characteristic feature of the vegetation in many parts of Australia and are widely distributed, being commonly known as "grass trees" (owing to the resemblance of the crown of leaves to coarse grass), "black boys" (because of the blackened trunks due to fires) or as "yaccas" or "yackhas". As the plants grow the basal leaves die but the leaf bases remain firmly attached to the trunk as a thick jacket, giving the plants the appearance of small palms at a distance. The resin is present on the trunk or between these old leaf bases. Fires or even the sun may cause it to melt and collect in globular form.

Some fourteen species of *Xanthorrhoea* (family *Liliaceae*) are known in Australia but only the following are regarded as important for resin:—

Xanthorrhoea hastilis. Eastern and south eastern Australia.
Xanthorrhoea arborea. New South Wales and Queensland.
Xanthorrhoea australis. New South Wales, Victoria and Tasmania.
Xanthorrhoea tateana. South Australia.
Xanthorrhoea preissii. South western Australia.

Two forms of the resin or "gum" are yielded by these plants, the yellow and the red. Yellow accroides is obtained from *Xanthorrhoea hastilis* but is comparatively rare, coming from far inland, while red accroides is obtained from any of the other above mentioned species. The collection of commercial supplies of the resin in the past has been mainly in South Australia, particularly on Kangaroo Island, where *X. tateana* is exploited. It has been estimated that about 15,000 tons of the resin would be available for collection there and that by suitable conservation of the trees a continuous supply could be maintained. In the years 1927-28 and 1928-29 South Australia contributed 98% of the total quantity of acaroid resin exported from Australia, supplying 47,694 cwts. in 1927-28 and 54,159 in 1928-29. In 1939-40 South Australia supplied 2096 tons and Western Australia 338 tons of resin. Production from the other states is said to be very small (Bull. Imp. Inst. 42:74-82).

An account of the method of collecting the resin on Kangaroo Island has been given by J. C. EARL (1917). After trimming and removing charred portions, the leaf bases with the adhering resin are cut away with an axe, an operation requiring some skill, and fall into a hessian covered framework. The material is later transferred to a "jigger", essentially an inclined sieve with two gratings, which separates the resin from the leaf bases and the bulk of the fibrous and woody matter. What remains is removed to a large degree by winnowing. EARL states it is customary though unnecessary, to chop off the crown of leaves on the tree. The tree often recovers even when so treated and sprouts again. In cases where the living leaves have not been removed the trees seem little affected by the removal of the dead leaf bases. In many cases trees have been stripped for "gum" twice or even three times at intervals of several years. A good deal of resin is lost as dust during the "jigger" process and winnowing. To avoid this a method of melting the resin from the leaf bases on trays by steam has been devised (Harrison Steaming Process). Solvent methods have also received consideration.

The resin has been employed mainly as a lacquer and varnish for metals. It has also been used in Australia for the manufacture of proprietory stove polishes and floor stains. On account of the rich colour and free solubility in alcohol the resin has been used in wood stains, also for leather varnishes. Varnishes and lacquers made from it are lacking somewhat in elasticity and toughness but are much improved by admixture with shellac. They are also inclined to darken quickly on stoving. The usually impure nature of the resin may have retarded its more extended use in the past. During the Second World War the red resin was freely used in connection with the manufacture of munitions in Australia, in pyrotechnical compositions and as a lacquer and varnish for metals. It was also imported into Great Britain, the United States, India and New Zealand. Other uses for accroides have been proposed from time to time such as the manufacture of sealing wax (with admixture of shellac, turpentine and chalk) and of picric acid. For certain purposes it may be used as a substitute for resin and shellac but is, in general, inferior to the latter. Some forms of *Xanthorrhoea* resin are slightly aromatic, especially when warmed.

Sandarac:—

African sandarac.—This resin, obtained from a small coniferous tree growing in the mountains of north west Africa, was known to the Ancients and to Mediterranean peoples in the Middle Ages, being used to some extent medicinally and as a picture varnish. The resin is pale yellow or orange and occurs in small tears or pieces mostly of cylindrical form—about .5 cm. thick and up to 3-4 cms long. It is brittle and breaks with a clear vitreous fracture. When chewed it forms a sandy powder in the mouth and does not agglomerate into a plastic mass like most resins. It is completely soluble in alcohol and partly so in turpentine and various other solvents. Sandarac contains about 1% of volatile oil but consists mainly of crystalline inactive pimaric acid (sandaracopimaric acid, 85%) and small amounts of sandaracinic and callitrolic acid.

The main use for sandarac has always been for varnishes of special types. It yields a hard, white spirit varnish inclined to be brittle unless mixed with other resins, with the gloss varying according to the solvent used. The resin has been much used as a metal varnish, giving good lustre in thin coats, also as leather and paper varnish and for indoor labels, etc. It has been employed in gold size and for glass and porcelain cements. At one time it was used in powdered form as "pounce" for preparing the surface of parchment for writing and also as incense, being somewhat aromatic. In present day pharmacy its uses are restricted but it is used in pill varnishes. An alcoholic solution on cotton wool has also been used as a temporary filling for teeth. Arabs used the resin for diarrhoea.

The tree yielding sandarac, *Tetraclinus articulata,* belongs to a monotypic genus and occurs mainly in the mountains of Algeria and Morocco where it is of importance for timber apart from the resin which exudes from the trunk. In Morocco there are extensive forests said to cover 350,000 hectares, above the 1400 metre level (Bull. Imp. Inst. **18**:100). The tree reaches 40-50 feet in height with a trunk 2-4 feet in girth. Its dark fragrant wood has been popular for cabinets and furniture for many centuries and was in favour with the Romans for roofing temples and for other purposes. The tree has been grown in other countries. On the southern coast of the Crimea it was found to be liable to be killed back in hard winters but to shoot again from the stump (I. A. ZABELIN 1935). In Great Britain the tree is doubtfully hardy even in the milder parts.

The resin has been exported largely from the port of Mogador in the past, hence the name "Mogador sandarac" often applied to it.

Australian sandarac.— Australian sandarac is very similar to the older and better known North African product but has been mainly consumed in Australia so far, and but little exported. In appearance and in chemical and physical properties it closely resembles African sandarac and has similar uses. It is derived from various species of *Callitris* endemic in Australia, this genus being closely allied botanically to *Tetraclinis.* There are some 18 species widespread in Australia and in New Zealand, all evergreen trees or bushes and commonly known as "cypress pine". They are well adapted for dry, arid regions and are among the most useful Australian conifers. Several species are valued for timber, yielding wood that resists attack by white ants. Others have bark rich in tannin. A detailed account of them has been given by R. T. BAKER and H. G. SMITH (1910).

Sandarac is known to have been collected from various species among which are—*Callitris arenosa, C. calcarata, C. glauca, C. macleayana, C. muelleri, C. oblonga, C. rhomboidea,* (syn. *C. cupressiformis*) *C. tasmanica,* and *C. verrucosa.* The species believed to be the main sources of resin are *C. calcarata* ("Black Cypress Pine") in the eastern states, *C. glauca* ("Murray River Pine") the most widely distributed species of the genus, and *C. verrucosa* also widely distributed, especially in the drier parts.

The resin exudes naturally from the trees but the flow may be stimulated by making incisions in the trunk. On drying or weathering the resin loses its glassy, pale yellow appearance and develops a whitish crust. It is usually slightly fragrant. Cypress pine resin is reputed to have been used by the aborigines of Victoria to make firm the union (after lashing) of the hardwood head to the reed in the making of reed spears (J. H. MAIDEN 1894).

Chemical investigation has shown that there are only very minor differences between Australian and African sandarac. The essential oil of African sandarac contained a diterpene and *d*-pinene whereas the Australian contained only *d*-pinene. Australian sandarac is often in larger pieces than the African (HEDLEY BARRY).

Mastic:—Mastic has been known and used in Mediterranean countries from a remote period and was mentioned by Theophrastus, who lived in the 4th century before the Christian era. The tree yielding it, *Pistacia lentiscus* (family *Anacardiaceae*), is widely distributed and occurs mainly in coastal districts, from Portugal and southern Spain to Greece, Syria and Palestine and in North Africa in Morocco and Tunis. The species is polymorphic and forms or varieties exist. Usually the plants occur as bushy shrubs but may reach the dimensions of small trees. It is a broad leaved tree form which is said to be exploited for mastic (Wolff). A variety (var. *emarginata* Engl.) has been recorded from British Somaliland and Kenya.

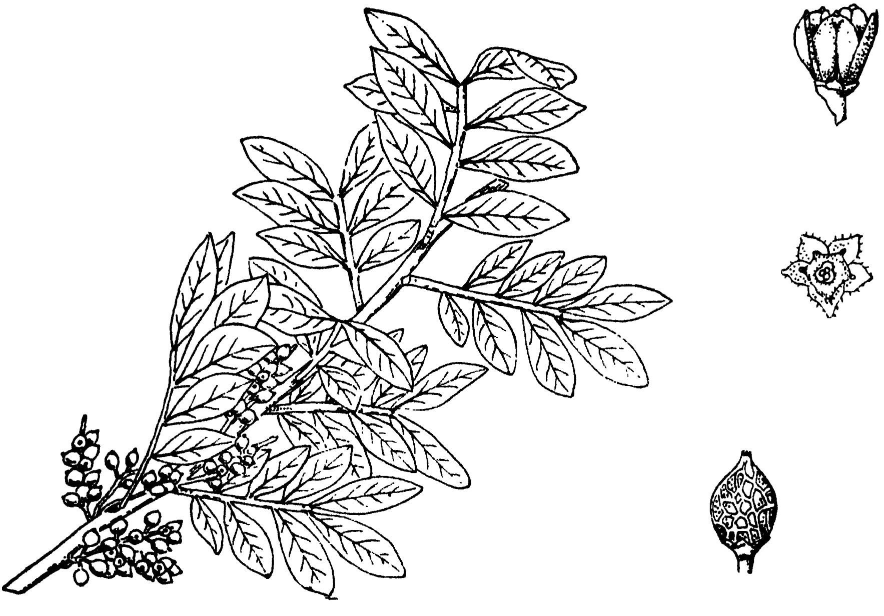


Figure 28.—**Pistacia lentiscus** L. The source of mastic and for centuries exploited in the eastern Mediterranean region.

The main source of supply of the resin, as far back as the middle ages, has been the island of Chios (Scio) in the Aegean, where the tree is abundant and the resin regularly and systematically collected. At one time the mastic of Chios was held as a monopoly by the Greek Emperors. Possibly neighbouring islands may also contribute some of the resin exported from Chios. At various times the resin has been obtained from other Mediterranean countries such as Cyprus, Samos, Pantellaria and Sicily but no regular trade appears to have been developed in them.

The resin is present in ducts in the bark of stems and branches but is absent in the wood. In Chios the inhabitants make numerous small vertical incisions in the bark of the stem and main branches about the middle of June and pick off the hardened resin three weeks or so later. As it often falls to the ground, clean, flat stones may be placed round the trunk or under the branches to catch the fallen resin and prevent contamination with soil. A certain amount of spontaneous exudation also takes place. Collection is commonly done by women and children and may extend over a period of about two months. A good tree may yield 8-10 lbs. of mastic in a season but after the fourth year the yield may fall considerably or cease altogether (FLÜCKIGER and HANBURY). Three distinct grades are recognized by dealers—(*1*) that picked from the tree (first grade) (*2*) that collected from the stones placed under the trees (second grade) and (*3*) that which has fallen on or become contaminated with soil. The tears are usually small, 4-8 mm. in diameter, but sometimes cylindrical pieces, up to 2 cm. long and 1 cm. wide occur. They are pale yellow, clear and glassy when fresh, brittle, and break with a conchoidal fracture. The resin is wholly soluble in benzol and ether and partly so in alcohol and turpentine.

The age long use of mastic in Eastern countries has been as a masticatory to sweeten the breath and preserve the teeth and gums, being of a sweet smelling or aromatic nature itself. It was also used medicinally and to flavour alcoholic beverages and cordials. Its use in medicine is now very much restricted. The main use of the resin has been in the manufacture of high grade varnishes of pale colour for special purposes, such as those employed for the protection of pictures in both oil and water colours. For this purpose it has the great advantage of being easily removed, either by solvents or by friction, without injury to the picture. The gelatinous material known to artists as "megilp" (from McGuilp the inventor), much used on account of its good working qualities, consists of mastic, turpentine and linseed oil.

Mastic has also been used in photography and in cements for precious stones or their imitations. A surgical varnish containing mastic (40 parts), castor oil (1.2 parts) and benzene (100 parts) is said to be used as a protective covering for wounds and to hold gauze and radium needles in position (Br. Pharm. Codex 1934).

Indian or Bombay mastic, which is very similar to Chios mastic but darker, is obtained from *Pistacia khinjuk* and possibly other species of *Pistacia*. This shrub or small tree is common in the mountains of Baluchistan and is also in Afghanistan.

Dragon's Blood:—Several resins of different botanical origins which are of a deep red or ruby-red colour have been known by the name of "dragon's blood" in the past. The first to attract attention was the "dragon's blood" of Socotra, from *Dracaena cinnabari*, a Liliaceous tree. This was alluded to by Dioscorides, Pliny and other early writers and was held in high esteem for its medicinal or its alleged medicinal properties, not only by the Greeks and Romans but also by the Arabs who knew it by the name of "dam-ul-akh-wain", a name which it retains among them at the present time. On the exploration of the Canary Islands in the 15th century a similar resin, from *Dracaena draco,* was one of the valued products collected by the early voyagers. The resin appears after incisions have been made in the stem. It has been found in the sepulchral caves of the original inhabitants but has never formed a regular or important article of trade with Europe.

At later periods East Indian and Malayan dragon's blood came to be imported and generally used in Europe, both for medicinal purposes and for coloured varnish. They are derived from the fruits of eight or more different species of *Daemonorhops*, climbing jungle palms and the source of rattan canes. Sumatra has been the main source of supply in the past with *Daemonorhops didymophyllus*, *D. draco* and *D. ruber* but resin is also collected in Malaya and Borneo from such species as *D. draconellus*, *D. mattanensis*, *D. motleyi* (Borneo), *D. micracanthus* and *D. propinquus* (Malaya). Any of these resin yielding rattans, which form a distinct group of the genus, may be known by the Malay name of "rotan fernang".

The method of collection of the resin varies in different parts (HEYNE). The resin is present as a brittle layer on the surface of the immature fruits, usually about the size of a cherry and covered with small imbricated scales. As the resin is inclined to loosen when the fruits ripen they are collected before they are fully ripe. In order to dislodge the resin, the fruits, after drying, may be placed in bags and beaten with sticks or put in baskets with cockle shells and shaken. The resinous powder thus obtained is sifted and then softened by heat and moulded into sticks or cakes. A good deal of impurity is generally present in the resin prepared in this way. Two forms of the resin have been marketed in the past, the "reed" and the "lump," the former having been moulded in the form of rods or sticks a foot or more in length and up to an inch in diameter and wrapped in leaves. The "lump" resin is in irregularly shaped masses, generally contains more impurity, and is of poorer quality. Batavia and Singapore have been the main ports of shipment in the past.

Good grades of East Indian or Malayan dragon's blood are dull red in colour, brittle and friable, and often covered with a dull crimson powder. The fracture is vitreous exposing an almost black surface, but when powdered appears crimson. It is almost devoid of taste or smell but emits an odour of benzoic acid when heated. In alcohol it is entirely soluble. The soluble portion consists of about 56% of a red resin (dracoresinotannol combined with benzoic and benzoyl acetic acids), 13% of a bright yellow amorphous resene (dracoresene) and 2.5% of a white amorphous body (dracoalban) (Br. Pharm. Codex 1934).

In European medicine dragon's blood was formerly used in dysentery and diarrhoea and as an astringent in tooth powders. It may be used as a colouing agent for plasters, but its main use has been as a constituent or colouring matter for varnishes. The great Italian violin makers of the 18th century are said to have made use of it for their varnishes. Nowadays it is little used, having been largely replaced by synthetic dyestuffs but has been employed for coloured spirit varnishes and lacquers for metals. Another use has been in zinc line engravings to protect those parts of the metal not to be etched from the action of the acid.

Chapter XIV

ELEMI

The name "elemi" is applied to a number of resinous products or oleo-resins that have appeared in commerce from time to time. They are derived from different botanical sources and from various parts of the world. TSCHIRCH enumerates no less than 46 different kinds, but the botanical sources of only a portion of these are known. They all have certain physical properties in common and consist of mixtures of resins and essential oils. Many are of semi-solid consistence and may be termed soft elemis to distinguish them from others, hard elemis, which are harder and rather like rosin in consistency. This distinction is a superficial one, for a soft elemi may become hard with the passing of time. The majority of elemis are aromatic or scented, owing to the high proportion of essential oil present, and are derived almost entirely from the family *Burseraceae*.

Manila Elemi:—Manila elemi, from *Canarium luzonicum,* a large Philippine tree, is the best known and most generally used kind. When fresh and of good quality this elemi is pale yellow, soft and granular, resembling crystallized honey, but on keeping and losing its volatile oil it darkens and sets harder. It has a fragrant, balsamic odour and a spicy, rather bitter taste. In alcohol and ether the oleo-resin is soluble, but only partly so in petroleum spirit. Examined microscopically it is seen to consist of numerous acicular crystals. In the fresh condition it contains as much as 20-30% volatile oil.

The present day uses of elemi are somewhat restricted. It may be employed in small proportions as a constituent of varnishes where it is desired to reduce brittleness or increase elasticity, but has to be used with care owing to its slow drying and "tacky" nature. Another use is in the manufacture of printer's inks, for which its honey-like consistence and adhesive character are particularly useful.

It also has medicinal uses, being employed as an ingredient in ointments where a small stimulant and antiseptic is required, but is now used much less than formerly. It may also be used in plasters. Probably its use for medicinal purposes has always been greater on the Continent of Europe than in Britain or America.

The greater part of the world's supply of elemi is normally derived from the Philippines in the form of "Manila elemi"—from *Canarium luzonicum.* This tree reaches a height of about 35 meters and a diameter of about one meter. It bears smooth pinnate leaves and small flowers in large compound inflorescences. The thick-shelled oval fruits contain an edible nut. The tree is abundant in the forests of Luzon and occurs elsewhere in the northern half of the Philippine Islands at low and medium altitudes *e.g.* in Marinduque, Ticao, Mindora and Masbate (WEST and

Brown). A local or Spanish name for the resin is "brea branca" (white pitch). It may be used by the natives in caulking boats and for torches. The "brea" is very sticky when freshly gathered and in making torches it is kneaded on the ground by beating with a piece of wood until sufficient dirt has been mixed with it to make it stiff, when it is rolled into shape and wrapped in a palm leaf. The torches give a brilliant light and burn for a long time.

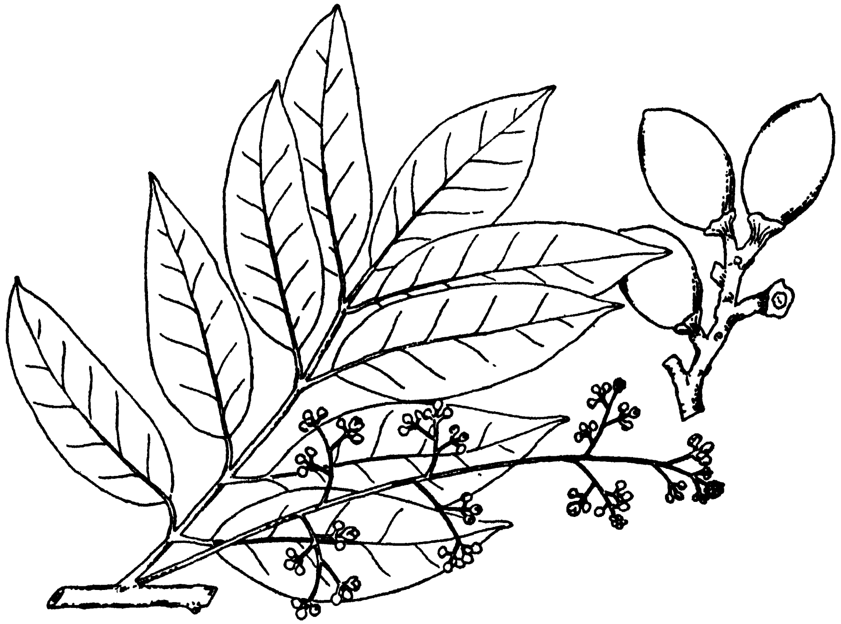


Figure 29.—**Canarium luzonicum** A. Gray. The source of Manila elemi (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by West and Brown).

The trees sometimes yield elemi very freely and may be tapped at almost all seasons, but towards the end of the dry season the flow is slight. Tapping consists of making gashes in the trunk and the resin is collected when it has exuded and partly solidified. It is usually collected about once a month and one man is said to be able to look after 75-100 trees. R. F. Bacon has observed as much as 32 kilos of resin on a large tree, the product of two months' accumulation and estimates that mature trees may yield an average of 45 kilos a year. The same writer found that there is much variation in the nature of the oleo-resin from tree to trèe. This may partly account for the variation that exists in commercial samples of Manila elemi. In addition to the elemi shipped to Europe and America, a good deal has been exported to China where it is reputed to be used for making transparent paper for window panes in place of glass.

Canarium luzonicum has been grown in plantations at Los Baños in the Philippines, the trees averaging 4.37 m. in height and 4 cm. in diameter after 7 years (West and Brown).

This species is regarded as the only source of commercial Manila elemi. Until comparatively recently, the true botanical source of Manila elemi was obscure and it was regarded as derived from a tree closely related to *Canarium commune*, the well known Java almond. In 1905, MERRILL showed that *Canarium luzonicum* was the only species, among the many species of *Canarium* in the Philippines, that was exploited for Manila elemi (BURKILL).

Other Elemis:—Among other elemis that have appeared in commerce in the past, but which are now seldom seen are the following:—

Yucatan elemi.—At one time Yucatan elemi was of some importance and the trade in it was second in volume only to that of Manila elemi. It is derived from species of *Amyris* (probably mainly *A. plumieri* and *A. elemifera*). In commerce it usually appears as hard, yellow, translucent pieces with an aromatic odour. It has been used in place of Canada balsam as a mounting medium in microscopical work.

Mexico.—Mexican elemi is somewhat similar and is also derived from species of *Amyris*, including *A. elemifera.*

Brazil.—The elemi exported from Brazil is commonly classified under four headings—true elemi, hard elemi, bastard elemi and yellow elemi. The so-called true elemi is believed to be obtained largely from *Bursera leptophloeos* and *B. gummifera* and the hard elemi from species of *Protium*, namely *P. icicariba* and *P. heptaphyllum* (F. W. FREISE 1934). There are about a hundred species of *Protium* in tropical America. Many occur in Brazil and are resin yielding. They are commonly known as "brea branca". The "tacamahaca" resin or elemi of Colombia and Venezuela is also thought to be derived from *P. heptaphyllum,* a widely distributed tree in South America ranging from Colombia and Venezuela to Brazil and Paraguay. It is said that where this tree grows the air in the vicinity seems pleasant and wholesome from the incense-like resin that drops from any wound in the bark and collects in masses on the ground. In the northern part of the tree's range the Indians use the resin, called "tacamaha" to scent the oil with which they anoint themselves (RECORD and HESS 1943). Bastard and yellow elemi (so-called) are stated to be derived from the Guttiferae, notably *Calophyllum brasiliense* and *Symphonia globulifera.*

West Indies.—West Indian elemi is collected from the "mountain gommier" (*Dacryodes hexandra*) a large handsome tree widespread in the West Indies at the higher elevations (E. M. HOLMES 1916). There are specimens in the Kew museum from Montserrat, Dominica and St. Vincent, collected in the latter part of last century. All are bright yellow and attractive looking. An account of the chemistry of this oleo-resin has been given by A. MORE.

Africa.—From time to time in the past small parcels or consignments of African elemi have appeared on the London markets, mainly from West Africa—notably Liberia, southern Nigeria and the Cameroons. Little is known of the botanical sources of such resins but it is thought that as far as Nigeria is concerned *Canarium schweinfurthii* may account for at least some of the resin. This large forest tree is abundant in some of the hill forests in Nigeria where there is a good rainfall. It has a wide distribution in tropical Africa extending from Sierra Leone to the eastern Sudan and East Africa. The fruits are edible and the tree sometimes planted on this account. On slashing the trunk, the odorous oleo-resin that exudes is at first colourless, but in time turns to a sulphur yellow colour. The resin burns readily with an incense-like odour and is sometimes used by hunters as flares (DALZIEL). It is also used by natives for fumigating dwellings and when mixed with oil for anointing the body.

A sample of the oleo-resin of *Canarium schweinfurthii,* obtained from Uganda, was examined at the Imperial Institute (Bull. Imp. Inst. 6:254-5). It varied in colour from white to pale yellow, but a good deal of vegetable debris and impurity was present. In properties it presented a general resemblance to Manila elemi but contained less volatile oil. It is considered that other African elemis, if collected in a clean condition and stored to prevent hardening and loss of oil, would compare favourably with good qualities of Manila elemi and could be used for similar purposes.

Mauritius.—An oleo-resin obtained from *Canarium mauritianum* in Mauritius is reputed to closely resemble Manila elemi (A. TSCHIRCH 1906), but may never have been of commercial significance. *C. mehenbethene* also yields a bright yellow, scented oleo-resin, specimens of which are in the Kew Museum.

East Indies.—The genus *Canarium,* which contains about 109 species, is well represented in the East Indies and the Malay Archipelago where close on 70 species are native. Many of these are known to yield oleoresins which may be of the elemi type although they may not be collected systematically. About a dozen species are listed by HEYNE for the Dutch East Indies and others by BURKILL for Malaya and Indo-China.

In the Solomon Islands, *Canarium salomonense,* a recently described species known locally as "tovinia" apparently yields a pale aromatic resin of the elemi type. A specimen collected by J. H. L. WATERHOUSE (in New Georgia) is in the Kew collection.

For descriptions of other elemis and their chemistry TSCHIRCH's well-known monograph should be consulted.

Chapter XV

NATURAL LACQUERS

The term natural lacquer or natural varnish is used for the sap or juice of certain trees which is collected in the liquid state and applied direct to the article or surface to be varnished, without the use of any outside solvent or drying agent. In the Orient such lacquers are in everyday use. The lacquer ware of China and Japan is perhaps the best known and has long been famous for its beauty, its artistic merit and the infinite care and skill that is devoted to its preparation. Good accounts of the historical and artistic aspects of this subject have been given by other writers (E. F. STRANGE 1924:1925). Other classes of lacquer work are carried out in Burma, Siam, Indo-China and Formosa, the resin being derived from different botanical sources from Chinese and Japanese lacquer, although all are trees belonging to the family *Anacardiaceae.*

Chinese and Japanese Lacquer:—Both Chinese and Japanese lacquer are derived from *Rhus verniciflua,* a handsome deciduous tree of erect slender growth reaching 60 feet in height. It is a native of central and western China and is largely cultivated by the Chinese. In the mountainous areas of Western Hupeh and eastern Szechuan, it is especially abundant and is most frequently met at elevations of about 4,000 feet. The tree was introduced to Japan at a very early period and flourishes in many parts of that country. There its cultivation is carried out mainly north of Tokio (between latitude 37° and 39°), in such situations as the borders of valley bottoms and in rocky soil and recesses where rice and other crops cannot be grown. The tree is sometimes cultivated in Britain and other countries on account of its ornamental foliage and handsome fruits.

When the tree is about 6 inches in diameter, tapping may commence and be carried out at intervals until the tree is 50-60 years old. Tapping is done in the summer and consists of making numerous parallel oblique incisions in the bark of the trunk and the main branches to the extent usually of about a quarter of the circumference. Midsummer is considered the best time for tapping, for in spring the sap is very watery and in the autumn thick and slow in exuding. Tapping is usually done in the early morning and a variety of different tools and sometimes gloves are used. The sap that exudes is collected in shells, bamboo tubes or other receptacles. It is whitish at first but soon darkens on exposure to the air. The sap continues to exude for about a week when the wound is freshened up by removing another layer of bark. This is repeated a few times after which the tree is allowed several years rest. On renewing tapping, the old wounds are opened up.

The raw varnish is often packed in wooden tubs bound round with straw rope to give protection in handling. Apart from the resin used in

China, which is considerable, large quantities have also been exported in the past, mainly to Japan and mainly through the port of Hankow.

The tree is propagated either from seed, sown in January or February, or from root cuttings about six inches in length and planted in rows in nursery beds. Ten years is the approximate age at which trees are ready for tapping, but they may be tapped earlier. At this age the yield is about 3 ozs. but it increases with the size or age of the tree. A single collector may tap from 600-800 large or 1,000 small trees in a season (Bull. Imp. Inst. 8:35).

The sap of *Rhus verniciflua* consists of resin (urushic acid), gum, water and a small quantity of albuminous matter. The gum keeps the resin in emulsion inside the tree and the albuminous matter is believed to play a part in the drying of the lacquer, a certain temperature and fair degree of moisture being necessary for its chemical action on the resin (BURKILL). The lacquer has the peculiar property of requiring a damp, not a dry atmosphere, to dry and harden, and this cannot be hastened by heat. For this reason special damp chambers are sometimes used by lacquer workers to harden their wares.

The Japanese acquired the art of lacquer work from the Chinese and developed it to a high degree of perfection. The methods employed in the case of high class work were often closely guarded secrets. As many as thirty different operations may be employed in preparing a single article, or over 300 different coats of lacquer applied with special lacquer ware, the work extending over several years. The first process is the preparation of the ground work on which the finishing coats and the decorations are to be applied. Cracks and joints in woodwork are filled with putty-like materials of which lacquer is a constituent. Inferior lacquer or lacquer mixed with materials like pottery dust or clay may be used for the first coats. After each coat the lacquer is allowed to dry thoroughly and is then rubbed down with charcoal powder and polished. With the groundwork completed the subsequent coats may be variously coloured, or glistening metallic dusts or pulverized mother of pearl employed, the whole being finally coated with clear lacquer or polished. The art of carving lacquer ware is of Chinese origin.

Burmese Lacquer:—The Burmese black varnish or lacquer, known to them as "thitsi" is similar in many respects to the Chinese and Japanese varnish already described, although the type of lacquer ware produced from it is quite different. The resin is obtained from *Melanorrhoea usitata,* a deciduous tree which occurs in various parts of Burma and in the native state of Manipur, in Siam and in Indo-China. In Burma and Manipur the tree occurs chiefly in the open forests. It has stout velvety branches and large leaves up to a foot long and six inches wide. The wood is hard and dark in colour. Under favourable conditions the tree is of rapid growth and may reach a size fit for tapping in 2-3 years (D. BRANDIS 1907). Tapping is carried out by making V-shaped incisions in the bark of the stem or branches with a special iron chisel and placing a bamboo collecting cup at the base of the V with its slanting mouth driven into the bark. The sap exudes as a thick viscid greyish fluid for about ten days, after which the wound may be freshened up. Old trees are said to produce more resin than those that are young and vigorous. They are tapped when in leaf (July to October) and yield no sap while leafless in the dry season.

This natural resin is used as a varnish for woodwork in Burma and for waterproofing paper or cloth, being employed for the characteristic Burmese umbrellas. Another of its common uses is as a cement. It is employed in making the glass mosaics used in the decoration of Buddhist temples.

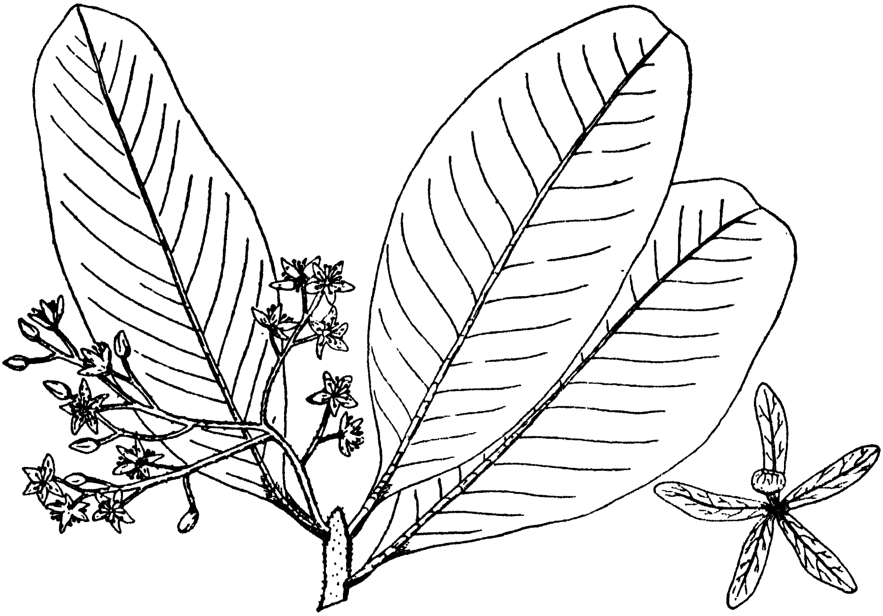


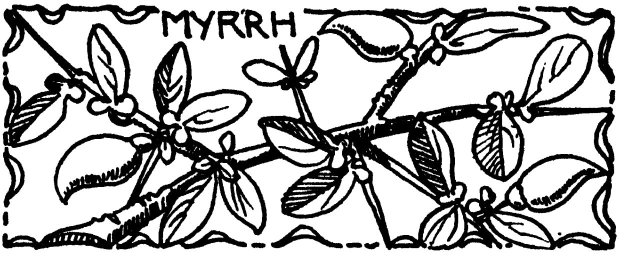
FIGURE 30.—**Melanorrhoea usitata** Wall. The source of Burmese lacquer or "black varnish".

In Burma different styles or types of lacquer ware are produced at different centres but the basic method of using the resin is the same, *i.e.* the application of several coats with thorough drying or polishing between each. It is fundamentally the same as with Chinese and Japanese lacquer work. Actually the resin is very similar to that used in China and Japan (from *Rhus verniciflua*). It consists mainly of urushic acid, which is also the main constituent of the resin of *Rhus verniciflua.* The other chief constituents are also similar. Like the Chinese or Japanese resin it requires a moist atmosphere to dry and harden properly. This peculiar property and the practical difficulties it implies is probably largely responsible for the fact that the resin has never made much headway among European varnish manufacturers (*see* Bull. Imp. Inst. **15**:42-46). The Burmese varnish is reputed to be less prone to set up dermatitis among those unaccustomed to it than is that from *Rhus verniciflua.* It is reported that during the First World War Chinese lacquer was imported to Britain for coating aeroplane propellers. As European workers developed dermatitis through working with it, Chinese workers had to be employed (HEDLEY BARRY).

The most distinctive types of Burmese lacquer work are—the lacquered basket work of Pagan, the Prome gold lacquered ware, the moulded lacquer ware of Mandalay and the Manipur varnished ware (sword sheaths, etc.). (Bull. Imp. Inst. 8:273-277).

Other Natural Varnishes:—In Indo-China a natural lacquer may also be obtained from *Rhus succedanea.* This tree, which is closely allied to the Chinese lacquer tree, is better known as the source of "Japan wax," a vegetable fat which is obtained from the fruits. It is used in polish manufacture, for finishing leather and for other purposes.

In Formosa, *Rhus ambigua* and *Semecarpus vernicifera* are said to be sources of natural lacquer (HEDLEY BARRY).



Chapter XVI

FRANKINCENSE AND MYRRH

Frankincense and myrrh are familiar names on account of the frequency with which they are referred to in the Scriptures and by classical writers. These resins or oleo-gum-resins, to use their more correct designation, are of little importance at the present time compared with their significance in earlier days. Nevertheless they still enter commerce. Their use by civilized man goes back to very early times indeed—well before the Christian era. Frankincense was one of the important articles of trade with the Phoenicians. A detailed account of it was given by Theophrastus. Myrrh was commonly used with frankincense and was a constituent of the celebrated "kyphi" of the Egyptians used in fumigation, in medicine and in embalming. Accounts of what is known of the early history of myrrh and frankincense have been given by other writers (TSCHIRCH's Handbuch der Pharmacognosie: FLÜCKIGER and HANBURY (1879)).

Frankincense:—Frankincense or gum olibanum as it is also called is obtained from members of the genus *Boswellia,* mainly *Boswellia carteri* and *B. frereana.* There are about a dozen species of *Boswellia,* all small trees or shrubs, that occur in the dry areas in north east Africa and southern Arabia. Ducts occur in the bark and other parts of the plant in which the oleo-gum-resin collects. By making incisions in the trunk or branches the resin exudes and solidifies and is collected by the natives as soon as it has hardened sufficiently (*see* the interesting old wood-cut on the frontispiece). As the resin is easily spoiled by rain collection takes place in the dry season. Like myrrh it is frequently despatched to Aden and then Bombay, the great emporium for gums and resins in the East, or it may be shipped direct to European ports.

In both British and Italian Somaliland *Boswellia carteri* and *B. frereana* are the species mainly exploited. The frankincense yielding areas in British Somaliland are extensive although not adequately known. They generally consist of rough, inhospitable or mountainous country which in itself makes collection difficult. The more accessible trees are often tapped while those in more remote places or difficult situations are left untapped. There are said to be large areas in British Somaliland where the trees are quite unexploited. Most of the resin or "gum" finds its way to Aden. On the way or in the 'godowns' blocking or consolidation of the tears commonly takes place which makes sorting difficult and expensive, and results ultimately in a lower price to the Somali collector. The opinion has been expressed that far better results would be obtained for all concerned were the frankincense bought and graded at Berbera and despatched direct to consuming countries rather than to Aden first, which considerably increases the likelihood of "blocking".

In Italian Somaliland the resins from *Boswellia carteri* and *B. frereana* are known respectively as "beio" and "inaidi" by the native collectors. Collection takes place mainly in the north of the colony in the arid Migiurtinia district where the trees commonly grow among rocks or in rock crevices with seemingly little soil for their nourishment and support. They are frequently in inaccessible positions, rocky ledges, etc., and much exposed to wind and weather.

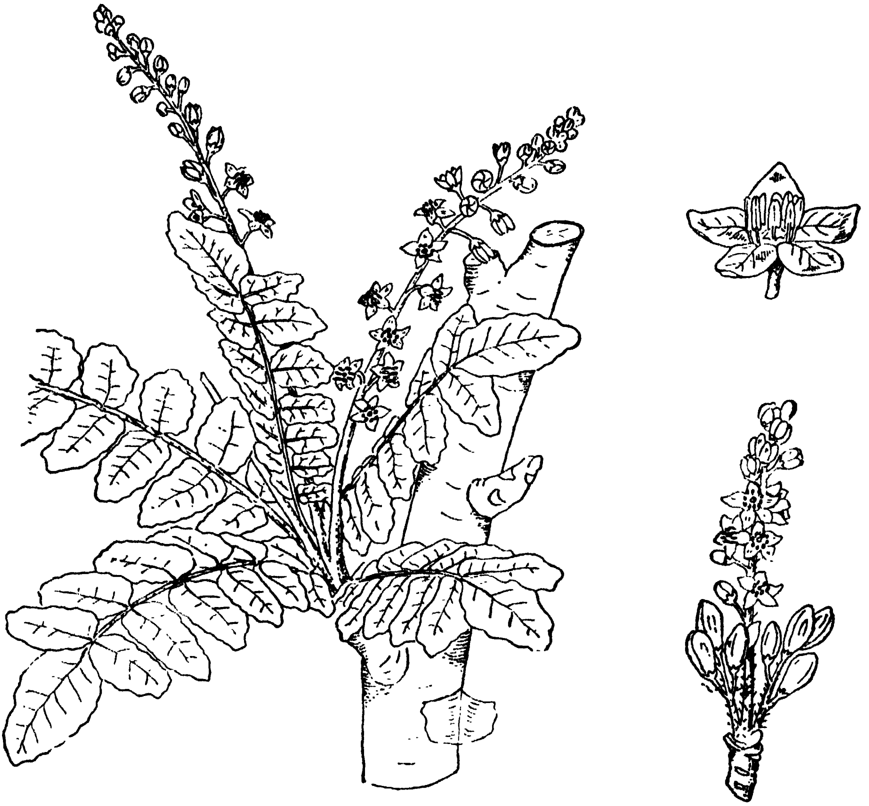


FIGURE 31.—**Boswellia carteri** Birdw. A source of Frankincense in Somaliland (*adapted from* Dr. M. C. COOKE'S Report on Indian Gums and Resins).

Tapping is carried out at the end of March or early April and is continued until about the end of September in the case of *Boswellia carteri* and the end of December in the case of *B. frereana*. Tapping is here carried out by scraping away portions of the bark and not by making "incisions" only in the tree. A special tool (termed "mengaff") is used. This is said to resemble a double scalpel, one end having a sharp edge, used for the decortication, and the other end being blunt and used in assisting to remove the resin when it has hardened. In tapping a wound 4-8 cms long is made and a single tree may be tapped in one or more places according to its size. After about a fortnight the resin which collects as globular, pear shaped or club shaped tears is removed and the wound freshened. Further collection is carried out every few weeks. At each collection it is customary to remove only the resin that collects on the wound itself, that which runs down the stem being left to accumulate and collected only once a year. This resin is of a transparent yellow colour with whitish streaks and constitutes an inferior or impure form. The practice is to suspend tapping of each tree every fifth or sixth year for it is realized a resting period is necessary for the trees if they are not to be exhausted.

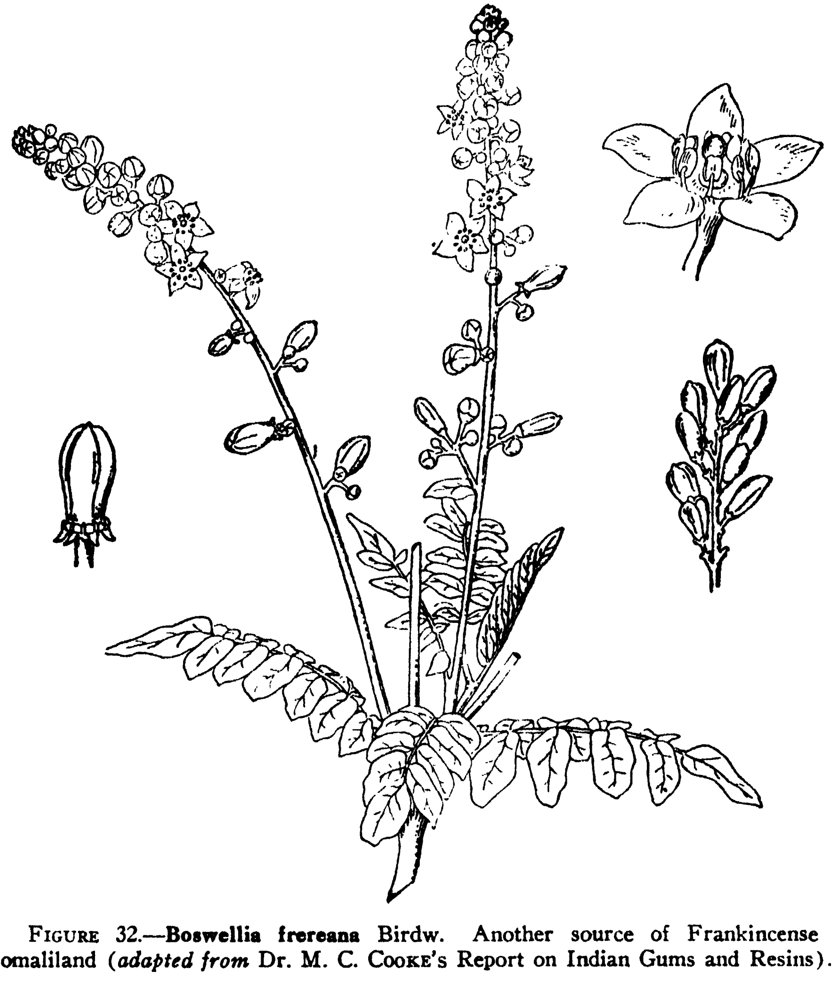


Figure 32.—**Boswellia frereana** Birdw. Another source of Frankincense in Somaliland (*adapted from* Dr. M. C. Cooke's Report on Indian Gums and Resins).

The mode of regeneration of the tree and the attitude of the natives to it in Italian Somaliland are indicated by the following remarks:—"Reproduction takes place by seed. The seed falls from the parent plant on to the rocks below, penetrates into one of the innumerable openings that the rocks present, finds there a little earth borne by the wind, germinates, puts out rudimentary leaves and a fleshy rootlet. For some time the young plant has a precarious existence, then it gradually gains strength and extends its root or enlarges its sucker according to the circumstances of its situation. . . . Certainly the natives do not concern themselves, and have never concerned themselves with the propagation of the precious plant—'Allah takes thought for everything, ours not to understand'. And with that convenient tribute to divine providence they are dispensed from any further trouble in the matter. It appears indeed that a descendant of the Osman Mahmud once tried to transplant some incense plants into open ground near the wady of Botiala, removing them from the mountain with great care, and with portions of rock adhering to their suckers. The plants, according to the story told by an aged chief, after a few years of exuberant growth came to grief in the waters that flooded the wady as a result of some exceptionally heavy rains. Allah had his revenge." (R. GUIDOTTI 1930).

The olibanum or frankincense of commerce consists of ovoid or pear-shaped tears, or stalactitic fragments, varying much in size, usually pale yellow, but often with a reddish or greenish tinge. They are brittle, easily broken with the fingers, and form a plastic mass when chewed. The taste is slightly bitter and the odour fragrant. Olibanum consists of resin (60-70%), gum (27-35%) and volatile oil (3-8%) (Br. Pharm. Codex 1934).

Frankincense is used mainly in the manufacture of incense, of which it is regarded as an essential constituent. Incense is employed particularly in the Roman Catholic and the Greek Churches. It is also employed in fumigating powders and pastilles. Its use in medicine has become obsolete in most countries.

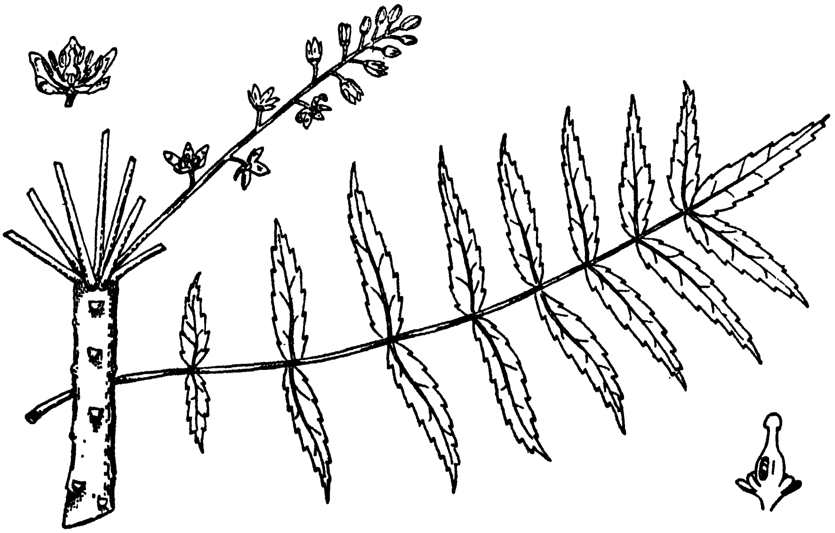


FIGURE 33.—**Boswellia dalzielii Hutch.** The sweet smelling resinous exudation is collected by natives in West Africa for their own use (*adapted from* The Flora of West Tropical Africa by HUTCHINSON and DALZIEL).

Other balsam yielding species of *Boswellia* are:—*Boswellia bhaudajiana, B. papyrifera* (north east Africa), *B. ameero* (Socotra) and *B. serrata* (India). The last mentioned is a common deciduous tree on dry hills in northern India, and is the source of the so-called Indian olibanum

This greenish oleo-gum-resin, which has been exported in the past (Bull. Imp. Inst. **13**:351-356) has an agreeable scent when burned and is used for incense, also medicinally in India as a diaphoretic and an ointment for sores (GAMBLE).

In some parts of the savannah areas of West Africa *Boswellia dalzielii* is one of the common trees and may even exist in pure stands. It is a small or medium sized tree, characterized by its pale papery bark that strips off. Its white fragrant flowers may appear before the leaves. The sweet smelling resinous exudation from the trunk is collected by natives and burned to fumigate clothing or to dispel flies and mosquitoes from dwellings. It is also used medicinally and in making malam's ink (DALZIEL).

Myrrh:—Myrrh is the aromatic resinous exudation from the trunks of several species of *Commiphora*, a large genus in the family *Burseraceae* consisting of some 160 species. All are African with the exception of about a dozen occurring from Arabia to India. Many have a characteristic bark that peels off in large papery pieces of its own accord. Myrrh is obtained from *Commiphora molmol* and certain other species and is collected mainly in Somaliland. These plants contain numerous schizogenous ducts in the bark and these may form large interconnecting cavities from which the gum-resin flows freely on wounding or from natural fissures in the bark. Fluid and yellowish white at first, it soon hardens to a reddish brown. After collection it is packed in goat-skins and sent to the coast for sale and export. It appears as irregular rounded tears or agglomerated lumps with a dull dusty surface. The odour is agreeable and aromatic and the taste bitter. Myrrh is in effect, an oleo-gum-resin, for its consists of a mixture of resin, gum and volatile oil, the resin content varying from 25-35%. The esteem in which myrrh was held in olden times and its use in incense, perfumes and unguents is well known. The Egyptians also used it in embalming. In addition, it has medicinal uses, being mildly disinfectant, and may be used as a local stimulant to the mucous membranes. However, myrrh is now of little importance compared with former times. In addition to Somaliland myrrh other sorts that have entered commerce are:— "Fadhli" or Arabian and "Yemen" myrrh.

The various bdelliums which resemble myrrh are believed to be derived in the main from species of *Commiphora*. Mecca Balsam or balsam of Gilead is stated to be derived from *Commiphora opobalsamum* a stunted bush or tree of Arabia. Indian myrrh or bdellium is obtained from *Commiphora mukul, a* small tree sometimes abundant in dry rocky areas in Baluchistan and northern India. The gum resin is used in native medicine and generally known as "mukal" or "gugal." Other species yielding resin, specimens of which are in the Kew collection, are *Commiphora drakebrockmanii, C. playfairii* (Somaliland), *C. erythraea* (Arabia) also termed opoponax (H. WOLFF 1928), *C. africana* (West Africa), *C. socotrana* (Socotra), *C. berryi* and *C. roxburghii* (India). It is of interest to note that the oleo-resin of *C. drake-brockmanii* ("habbak dunkel") is reputed to be used by the Somalis for poisoning leopards (Kew Bull. 1933:511-512). In Tanganyika *C. merkeri, C. schimperi, C. fischeri* and *C. kyimbilensis* are known to be "gum" yielders but are not exploited (B. D. BURTT 1935).

Chapter XVII

MEDICINAL AND OTHER RESINS

Abies:—The most important resin yielding species in this large genus is the balsam fir (*Abies balsamea*), one of the most widely distributed conifers in North America and the source of Canada balsam, or "Canada turpentine" as it is also termed. The tree reaches 50-70 feet in height and 2½-5 feet in girth. It extends from Labrador to Virginia and is common in low lying swampy ground but ascends to an altitude of 5,000 feet. It was introduced to Europe in the 18th century but has never been cultivated to any extent. In Britain it is short lived and considered to have no value for ornamental purposes.

The oleo-resin is located in schizogenous ducts or "blisters" in the bark. These are not present in the wood. It is often collected by puncturing the blisters with the pointed spout of a can, the latter serving to collect the balsam. Much of the collection takes place in the province of Quebec. When fresh, the oleo-resin is pale yellow and may have a greenish fluorescence. It is transparent and viscid with an agreeable terebinthinate odour. It contains 16-20% volatile oil and 70-80% resin and dries forming a hard transparent film. A feature of Canada balsam is the little tendency it shows to granulate or crystallize on drying. This, combined with its high refractive index, approximating to that of glass, accounts for its use in microscopic work and as a cement for lenses in optical work. In recent years it has been supplanted to some extent by synthetic preparations. For microscopic use, the natural volatile oil is first driven off by heat and the resin then dissolved in xylol or other suitable solvent.

The Douglas fir (*Pseudotsuga taxifolia*) and the hemlock spruce (*Tsuga canadensis*) yield somewhat similar balsams, the former being sometimes termed Oregon pine.

The so-called Alsatian or Strasburger turpentine (a Continental drug) is obtained from *Abies pectinata* (common silver fir) in much the same way as Canada balsam is obtained (G. E. Trease 1945).

Ailanthus:—In western peninsular India and elsewhere in India and Ceylon, the oleo-resin of *Ailanthus malabarica* ("mattippal") is commonly collected and much esteemed for medicinal purposes (diarrhoea and dysentery). When first collected, often in bamboo joints, the balsam is grey, very soft and viscid, but hardens on exposure and becomes reddish brown (K. R. Kirtikar and B. D. Basu 1918).

Aloe:—A certain amount of resin is present in the dried leaf juices of the several species of *Aloe* which constitute the aloes of commerce. The four varieties official in the British Pharmacopoeia are the Cape, Curaçao, Socotrine and Zanzibar aloes. Similar methods are adopted in the collection and preparation of all these aloes, the cut leaves being allowed to drain into some suitable receptacle and the juice evaporated either in the sun or, more commonly, with artificial heat. The rate of evaporation has a profound effect on the final product. If rapid, and carried as far as possible, the drug is transparent with a glassy or vitreous fracture, whereas with slow and moderate concentration of the juice it is liable to be crystalline and opaque—termed "livery" or "hepatic."

The main constituents in the drug are crystalline glycosides, the resins present being only of secondary importance.

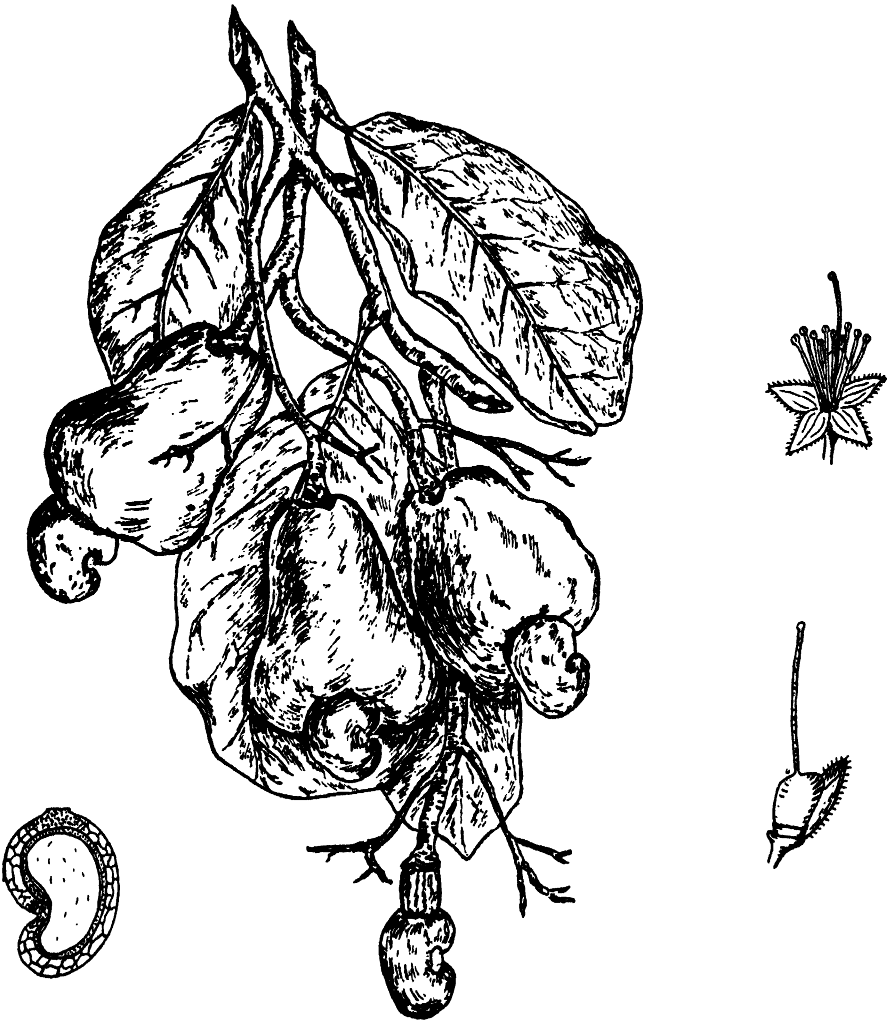


Figure 34.—**Anacardium occidentale L.** (cashew). **Cashew nut shell liquid is now used in the manufacture of certain synthetic resins and plastics.**

Anacardium:—An account of the cashew nut tree, its distribution and the gum sometimes obtained from the trunk has been given in Chapter

V. This tree is also now the source of a valuable raw material used in the manufacture of synthetic resins and plastics. The dark, tarry shell "oil" which collects during the roasting process of the nuts has been regarded in the past mainly as a nuisance on account of its strongly vesicant properties. Phenols, the raw material of certain much used plastics and synthetic resins, are rarely found in nature in quantities that justify their extraction. However, cashew nut shell liquid is a rich source of them and probably the only economical vegetable source. This fact was first realized and developed some 15-20 years ago in the United States when it was demonstrated that cashew nut shell liquid was a raw material with a phenolic content capable of yielding a series of resins of considerable potential value. A number of patents covered the initial discoveries and these led to commercial application of the resins for various purposes.

The resinous materials from cashew nut shell liquid are prepared by thermal or catalytic polymerization or by condensation with aldehydes, or by a combination of both processes. These resins are in general thermosetting but are more flexible and rubbery than the conventional thermosetting phenolic resins, which gives them additional uses. If polymerized to a viscous stage reaction with paraformaldehyde takes place in the cold giving a solid mass of considerable resiliency. This has been found to be a valuable cold setting compound for various electrical purposes such as splicing power cables, filling magneto coil housings, condenser cases and terminal boxes. In America such topping and filling compounds are known as "oil stops" and are supplied to cable contractors in two compartment tins, one with resin the other with paraformaldehyde. After mixing setting takes place in 30-90 minutes (J. D. MORGAN 1945).

The second world war seriously affected the Indian cashew nut kernel industry and the kernel industry directly affects supplies of shell "oil" or liquid. In 1939 the United States imported some 5000 tons of cashew nut shell liquid (sometimes termed "C.N.S.L.") and it has been estimated that potential yearly supplies from India, based on the pre-war kernel output would be about 15,000 tons (V. E. YARSLEY 1945). Normally East African cashew nuts are sent to Indian factories for processing so that the shell liquid would become available in that country. The shell liquid is present in the shell to the extent of about 35% and exists in irregularly shaped cavities in the shell tissue.

Anisoptera:—In the Philippines a resinous oil ("palosapis" resin) is obtained from *Anisoptera thurifera* a common and widely distributed tree. The resinous oil is similar to that obtained from *Dipterocarpus* ("Gurjan") and has similar uses. (WEST and BROWN).

Araucaria:—Unlike most Conifers, the Araucarias yield gum-resins rather than pure resins or oleo-resins. In the case of the Parana pine (*A. anugustifolia* syn. *A. brasiliana*) which forms pure stands or forests in parts of Brazil and is the most important timber tree of that country, the gum resin ("resina de pinneiro") may exude freely from old trees, especially after damage by beetles, and soon hardens in the air. In Australia gum-resin has been collected from *A. cunninghamii* and *A. bid-*

willii and in New Caledonia from *A. columnaris* (syn. *A. cookii*) and *A. rulei* (MAIDEN 1901).

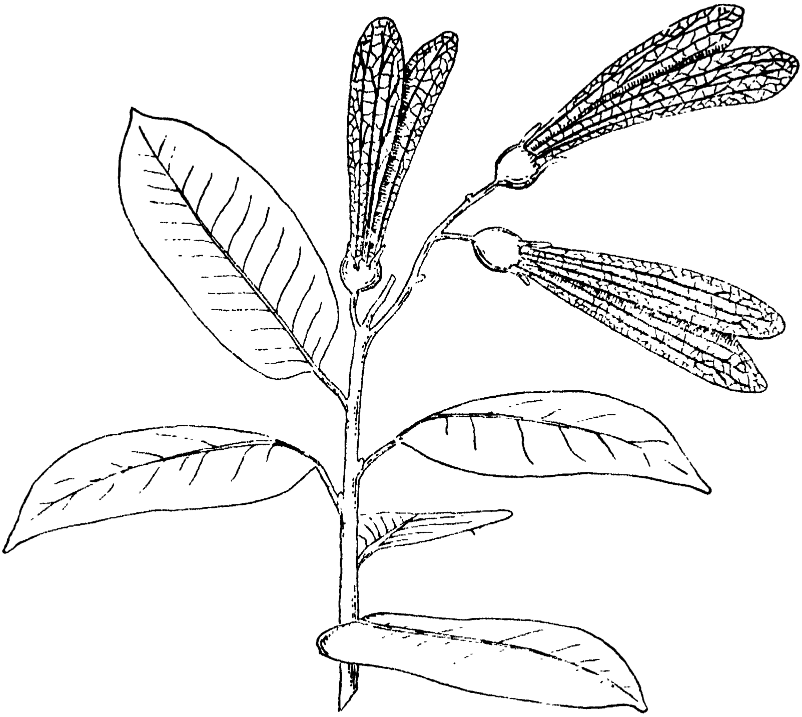


FIGURE 35.—**Anisoptera thurifera** Blanco. Yields a resinous oil in the Philippines similar to gurjan oil (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by WEST and BROWN).

Artocarpus:—The dried latex from the Jak tree, *Artocarpus heterophyllus,* a well known fruit and timber tree in the tropics, is rich in resin. A sample of the dried juice or latex from Ceylon, where the tree is extensively grown, was found to contain two resins *viz.*—51.2% of a soft pale coloured resin, soluble in petroleum ether, with a melting point of about 38°C., and 23% of a hard, dark coloured resin, insoluble in petroleum ether with a melting point of 100-101° C. It is not known that the latex, which contains caoutchouc-like and other materials is likely to have any commercial utilization. (Bull. Imp. Inst. **38**:294-299).

Bursera:—About a hundred trees and shrubs, widespread in tropical America, belong to this genus. Some are sources of essential oil (linaloe). One of the best known species is perhaps the West Indian birch (*Bursera simaruba*), also termed "incense tree," "gommier" or "gumbo limbo." This is a large deciduous tree that extends from southern Florida through central America and the West Indies to Colombia and Venezuela. Among Spanish speaking people it is known as "almácigo" and is recognized by its smooth reddish bark that scales off in papery pieces. All parts of the tree are resinous and a fragrant gum-resin is sometimes collected from the trunk. This has been used in the West Indies for flambeaux or torches and as incense in Roman Catholic churches. Mexican elemi is believed to be derived partly from species of *Bursera* (*see* page 143).

Cistus:—Ladanum or Ǐabdanum, a fragrant resinous substance used in perfumery and in scenting certain classes of tobacco and soaps, is obtained from various species of *Cistus* or "rock rose" in the Mediterranean region. Spanish ladanum is obtained by boiling twigs of *C. ladaniferus* and skimming off the resin that comes to the surface. Solvent extraction processes may also be used, especially in France, and are superior, causing less loss of aroma. The resin may be collected by combing it from the fleeces of sheep and goats, as in Crete, where *Cistus creticus* is the source. Other sources are—*C. albiflorus, C. maculatus* and *C. stenophyllus* (FINNEMORE).

Ladanum is usually in dark brown cakes and contains 40-80% resin and 1-2% volatile oil. There are many grades differing in colour and perfume. The French grades are among the best. Ladanum is no longer used medicinally, but may be employed in fumigating pastilles. It is the nearest approximation to ambergris in the Vegetable Kingdom and is a valuable fixative in perfumery. It is a constituent of most artificial ambers. A form of ladanum has also been obtained in Brazil (F. W. FREISE 1934).

Convolvulus:—The root of *Convolvulus scammonia* or scammony, a climbing plant of the eastern Mediterranean region, contains resin which has been employed as a drug. It is now little used, other forms of scammony (*Ipomoea* spp.) having taken its place.

Copaifera:—Copaiba or balsam of Copaiba is the oleo-resin obtained from the trunk of *Copaifera langsdorffi* and other South American species of *Copaifera.* It is collected, mainly in Brazil, either by making "V" shaped incisions, by boring holes in the trunk, or by cutting cavities in the base of the trunk in which the balsam collects in much the same way as trees are "boxed" for turpentine. Its uses are entirely medicinal, being employed mainly in inflammatory affections of the bladder and urethra and sometimes in bronchitis. The oil rather than the resin is the active constituent.

There are various commercial varieties of Copaiba balsam differing somewhat in appearance and composition. These are known by the names of the towns from which they are exported, *e.g.* Para, Maranham, Maracaibo and Savanilla. Other species reputed to yield copaiba balsam are—*C. reticulata, C. guianensis, C. multijuga, C. officinalis, C. martii, C. glycycarpa* and *C. coriacea* (F. W. FREISE 1934).

Dipterocarpus:—A liquid oleo-resin or "wood oil" is obtained from various species of *Dipterocarpus* in south east Asia, particularly *D. turbinatus,* which yields gurgan balsam and is a common and much exploited tree in Burma. The oleo-resin somewhat resembles copaiba balsam in odour and taste but is darker. In other parts of the eastern tropics, *e.g.* Malaya, Java, Siam, Indo-China and the Philippines numerous other species are tapped for their resinous oil. Among the Philippine species two of the best known are *Dipterocarpus grandiflorus* and *D. vernicifluus* (West and Brown). All the species of the genus, some seventy in number, contain resinous oil (Burkill). The resin ducts are sometimes as large as 2 cm. in diameter (von Wiesner). The usual method of obtaining the oil is to cut a hole in the trunk near the base and to dip out the oil with a coconut shell or other receptacle as it collects there. To prolong the flow a fire may be lit in the hole at intervals, using brushwood, dead leaves, etc. This has the effect of burning off the dried resinous film and so re-exposing the cut surface. These resinous oils have various local uses. They are employed to some extent medicinally, also for torches, caulking boats (mixed with other substances) and for varnishing the interior of houses. As natural varnishes they are far from ideal as they are prone to become brittle and require constant renewal.

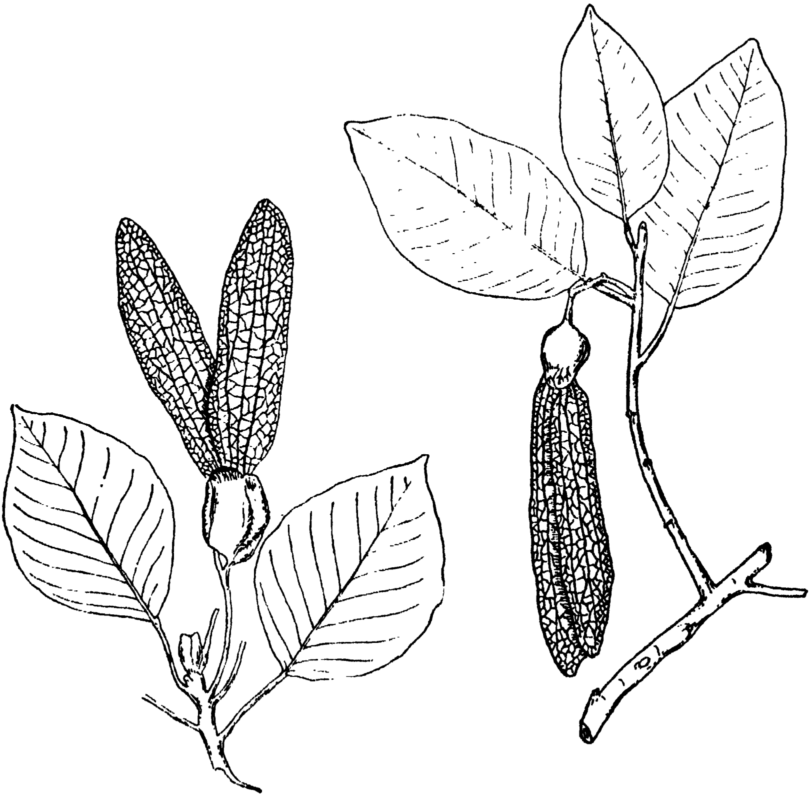


Figure 36.—**Dipterocarpus grandiflorus** Blanco (*left*) and **D. vernicifluus** Blanco (*right*). Both species may be exploited for their resinous wood oil in the Philippines (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by West and Brown).

Dorema:—The gum-resin known as ammoniacum, a well known drug, is obtained from *Dorema ammoniacum* and probably other species such as *D. aucheri*, tall perennial plants of Asia Minor. *D. ammoniacum* reaches 6-8 feet in height and has large compound leaves. It is very common in some areas, even to the extent of being the dominant plant in the vegetation, as in parts of Persia, which has always been the main source of commercial supplies of the drug. The milky resinous juice exudes from the stems in droplets as a result of insect injury. This may dry on the stems or fall to the ground where it is collected.

The drug appears in commerce in two forms, tears (the purer and superior form) and nodular masses (lump ammoniacum). When fresh it is pale yellow but darkens with age. The odour is characteristic and the taste bitter and acrid. Taken internally ammoniacum is of value in bronchitis, being excreted by the bronchial surfaces and facilitating expectoration. It is also used in plasters.

Other forms of ammoniacum known to commerce are the African or Moroccan and the Cyrenian, both believed to be derived from species of *Ferula.*

Elaeagia:—Resin is obtained from the buds of *Elaeagia utilis,* a shrub or small tree that occurs in Colombia at altitudes of 2300-2500 meters. It is collected and used locally as a varnish or lacquer for coating furniture and ornamental articles of various kinds. The centre of this little known industry is stated to be the town of Pasto, hence the name "Pasto lacquer" or "barnitz de Pasto" applied to it (L. A. LEON 1944).

Euphorbia:—A certain amount of resin is contained in the milky juice or latex of Euphorbias. The dried latex of *Euphorbia resinifera* is a commercial article and well known drug—"gum euphorbium" but the resin present does not constitute the active principle. This fleshy cactus-like plant occurs in Morocco where the dried latex is collected after wounding by the natives who place a cloth round the mouth and nose to prevent breathing the dust as this is acrid and causes violent sneezing if inhaled. The main use of the drug is in veterinary practice as a vesicant. Ammoniacum has also been used in the preparation of anti-foul compounds for ships' bottoms.

The resins present in the latices of other Euphorbias have so far shown little promise of commercial utilization. Those of the rubber or potential rubber yielding species such as *Euphorbia tirucalli* have been investigated (Bull. Imp. Inst. **13**:361). In general their low melting point means that as varnishes they are prone to become sticky or tacky in hot weather and the film becomes rough and opaque due to crystallization.

Ferula:—This large genus of the *Umbelliferae,* so well represented in the Mediterranean region and central Asia, contains species yielding oleo-gum-resins that are of medicinal value and have been known in trade from the earliest times, such as asafoetida, galbanum and sagapenum.

Asafoetida is collected from the living root of *Ferula foetida, F. rubricaulis* and probably other species that grow in eastern Persia and western Afghanistan. The soil is first scraped away from the crown of the plant exposing the carrot-like root, which may be several inches in diameter. A portion of the root is then cut away or the stem cut off at ground level. After the juice that exudes (contained in large schizogenous ducts) has dried sufficiently it is collected. Dried leaves and branches or stones may be placed over the exposed root for protection. Another method of collection, practised in the Fars district, is stated to consist of cutting off the head of the plant and collecting the exudation, and cutting the stem back again subsequently (G. E. TREASE 1945). The drug enters commerce in three forms—"paste", "tear" and "mass" (block or lump), mainly the latter. It is generally mixed to some extent with extraneous vegetable or earthy matter. Good samples contain 40-64% resin, 10-17% volatile oil and 25% gum (H. G. GREENISH 1929). The drug has a penetrating alliaceous odour and bitter taste. It is used as a carminative in flatulence and as a sedative in nervous disorders, also as an enema in internal flatulence. Other uses are in veterinary medicine and as a constituent of certain sauces. (TREASE 1945).

Galbanum is a product similar in many respects to asafoetida. It is derived from species of *Ferula* (*F. galbaniflua* and probably other species) and is also indigenous and widely distributed. Like asafoetida it is obtained by laying bare the root and cutting away a portion or cutting the stem off at the root. Some of the drug is also obtained from natural exudations on the stem. Galbanum is exported from the Persian Gulf ports, either as lumps or in the form of distinct tears, the tears being softer than those of asafoetida. It consists of resin (50-70%), volatile oil (5-20%) and gum (about 20%). It is used as a stimulant expectorant in chronic bronchitis and externally in the form of plaster for inflammatory swellings (Br. Pharm. Codex 1934).

Sagapenum is the oleo-gum-resin obtained from species of *Ferula* (possibly *F. persica or F. szowitziana*) in Arabia and Persia. It has a bitter nauseous taste and an odour more aromatic and not so strong as asafoetida. It has been employed similarly to asafoetida and galbanum. Both sagapenum and opoponax, a similar resin, are no longer common.

Garcinia:—A number of Garcinias in the eastern tropics are known to yield gum-resins, the best known being *Garcinia hanburyi* (Indo-China) the source of commercial gamboge, and *G. morella* of western India which yields Indian gamboge. Gamboge is collected mainly in the islands on the east coast of the Gulf of Siam, the Siamese province of Chantaburi and also in Cambodia and lower Cochin-China. Its common Siamese name is "rong". To obtain the gum-resin a spiral is cut round the trunk from a height of about 10 feet, in the rainy season, when the sap flows freely, and a bamboo cup or joint placed at the base to receive it. When dry enough the resin is either moulded into cakes or placed in bamboo moulds to be later loosened by heat. These yield "pipe gamboge", which is usually the better grade.

Gamboge consists essentially of a mixture of 70-80% resin with 15-25% gum. In the East it is used primarily as a pigment, the yellow silken robes of Buddhist priests being sometimes dyed with it. It makes the golden yellow ink of Siam used for writing on locally made books of black paper (BURKILL). In western countries it has been employed medicinally, as a hydragogue cathartic, but is now seldom used. It is a well known pigment in water colour painting and is also used for making gold coloured spirit varnish for metals. Indian gamboge (*G. morella*) is similar in its properties and uses but does not appear to have been regularly exported from India.

Gardenia:—Certain species of *Gardenia* yield resin freely which may be secreted on the buds and young shoots. With two Indian species, *G. gummifera* and *G. lucida,* the shoots and buds are broken off with the drops of resin attached and sold in the bazaars ("dikamali" gum). They are sometimes pressed into cakes. The resin itself is greenish yellow and strong smelling. It is employed in various ways in native medicine. Gardenia bud resin has also been collected (from other species) in New Caledonia and Tahiti (DE CORDEMOY).

Guaiacum.—The drug known as guaiacum resin is obtained from the heartwood of *Guaiacum officinale* and *G. sanctum* in the Caribbean region, these woods being the lignum vitae of commerce. The resin is present in the heartwood to the extent of 18-25% and may be obtained in various ways, *viz.*—by burning the log at one end (after boring with an auger) which causes resin to flow from the other, and by boiling the sawdust or wood waste in sea water, or extracting with alcohol or other solvent. Tears may also be collected from the living tree. The resin is usually marketed in the form of large blocks, dark in colour and covered with a greenish powder. It has a balsamic odour, especially when warmed, a slightly acrid taste, and consists actually of a number of different resin acids (Br. Pharm. Codex 1934). The action of guaiacum is that of a local stimulant. It has various medicinal uses.

Ipomoea.—The tuberous roots of several species are known to contain resin. In some instances the resins are of medicinal value as purgatives, *e.g.* jalap (*Ipomoea purga*), Tampico jalap (*I. simulans*) and ipomoea (*I. orizabensis*).

Laretia:—The sole representative of this genus, *Laretia acaulis,* an Umbellifer occurring in the Andes of Chile, is reputed to yield a gum-resin similar to galbanum (TSCHIRCH 1906).

Larix:—The common European larch (*Larix decidua*) is the source of the oleo-resin known as Venice turpentine, collected mainly in South Tyrol. Unlike most Conifers the resin ducts are mainly in the centre of the trunk, not near the surface, consequently it is obtained by boring holes into the trunk. This is done in the spring, the orifice being closed until the autumn when collection takes place. Boring may take place as soon as the boles have attained a diameter of about a foot. A single hole is made, which may suffice for the rest of the life of the tree, possibly 20-30 years. The yield may average only about 2 oz. per tree. Venice turpentine was of some importance two centuries ago (HEDLEY BARRY). One of its uses is in veterinary medicine.

Liquidambar:—Storax is the oleo-resin obtained from *Liquidambar orientalis,* a medium sized tree that forms forests in Asiatic Turkey. To obtain the oleo-resin the usual method is to beat the bark in places in early summer. The oleo-resin collects in the spongy bruised bark which is removed in the autumn and the balsam extracted by boiling in water and pressing. Crude storax is a viscid semi-fluid substance, greyish in colour, with a pleasant aromatic odour. The purified product is semi-transparent and yellowish brown. Its medicinal uses are similar to those of Peru balsam and benzoin, but it is now seldom used.

American storax or sweet gum is a similar product obtained from the allied species *Liquidambar styraciflua.* This tree extends also into Mexico and the highlands of Honduras and Guatemala. The resin, called "xochicotzo" by the ancient Mexicans and used in medicines and perfumes, was an article of tribute for the support of the central government (Record and Hess (1943).

Myroxylon:—Two important tropical American trees belong to this genus—*Myroxylon pereirae* the source of Peru balsam and *M. balsamum* (syn. *M. toluifera*) the source of Tolu balsam. They are closely related,

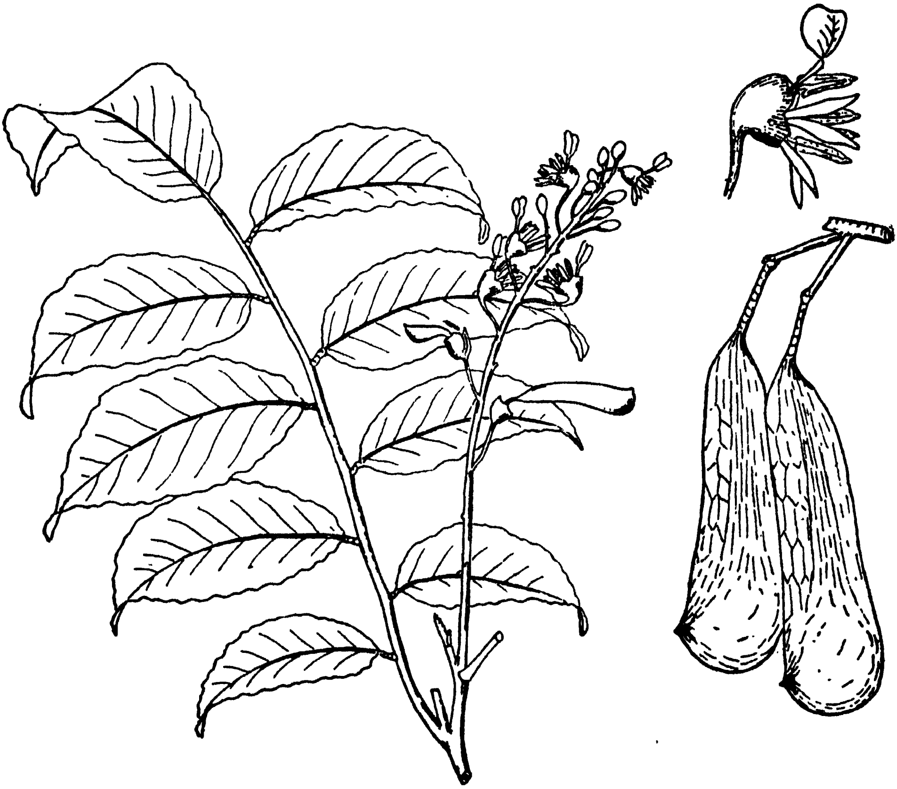


Figure 37.—**Myroxylon pereirae** Klotzsch. The source of Peru balsam.

so much so in fact that some are inclined to regard them as a single species (Record and Hess 1943).

Peru balsam was introduced to Europe by the Spaniards as early as the sixteenth century. The tree yielding it extends from southern Mexico southwards through central America, mainly on the Pacific side. It grows as high as 100 feet with a trunk up to 3 feet in diameter, but is usually smaller. The vanilla scented resin or balsam has always been mainly exploited on the Balsam Coast, a strip of territory on the Pacific coast originally part of Guatemala, now of Salvador. There the tree occurs in abundance. Formerly the balsam was taken to Calloa in Peru for transshipment to Spain, hence the name "Balsam of Peru", but now it is shipped direct to consuming countries. The annual production of Peru balsam in Salvador is about 115,000 lbs., of which nearly half is exported to the United States. At the present time Peru balsam is mainly exported from Acajutla (San Salvador) and Belize (Br. Honduras) in tin containers holding about 27 kilos (TREASE 1945).

The usual Indian method of obtaining the balsam is somewhat crude and liable to injure or kill the tree. The trunk is first beaten in several places over a surface of about half a square foot to loosen the bark and the outer portion of the bark removed. The exposed surfaces are then covered with a piece of cloth to absorb the exudation. At intervals later the surfaces are scorched with a torch and then the inner bark removed to induce a still further flow. Eventually the rags are boiled and pressed to separate the balsam. The tree does not normally exude the balsam to any extent, hence the special treatment.

In tropical America the tree is sometimes planted as shade for coffee and has been grown in various other parts of the tropics (F. N. HOWES 1929). Tapping experiments in Surinam showed that with the native Salvador method trees took eight years or more to heal, whereas a modified method, removing only long narrow strips of bark at wide intervals on the bole, and using a hot iron instead of a torch to heat the exposed part, healing took place in six months, even with three burnings. Continuous annual yields of 3 kgm per tree with 20 year old trees were regarded as possible with these methods (*see* Kew Bull. 1929:327-329).

Peru balsam consists of 53-66% of a colourless aromatic oily liquid, and about 28% of a dark resin. In Salvador the best trees are said to yield between 4 and 5 lbs. of balsam a year. Formerly credited with great medicinal value, it is now mainly used for its perfume in ointments and proprietary preparations. It is used in perfumery and soapmaking. Medicinally it has been used externally as an antiseptic and parasiticide, especially in scabies.

The tree yielding Tolu balsam (*Myroxylon balsamum*) is widely distributed in South America, being common in parts of Brazil and the Argentine, where its timber is exploited commercially to some extent. Most of the Tolu balsam that enters commerce is obtained from Colombia and Venezuela (RECORD and MELL). To obtain the balsam trees are tapped by cutting V-shaped gashes in the bark and using calabashes to collect the resin, which is transferred to skin bags for transport to the coast and finally put into tins for export. The name Tolu is derived from that of a small town near Cartegena in Colombia. When fresh the balsam is a soft, tenacious, yellowish brown mass but in time hardens and eventually becomes brittle. It has a pleasant fragrant odour and balsamic taste. The balsam contains about 80% resin.

Tolu balsam is used in the perfumery industry and for medicinal purposes, being employed chiefly as a pleasant ingredient in cough mixtures.

It possesses antiseptic properties owing to the cinnamic and benzoic acids that are present. The balsam has also been used as an adulterant of the more valuable Peru balsam.

Picea:—The common European or "Norway" spruce *Picea abies* (syn. *P. excelsa*), which is a native of most of the mountainous parts of central and northern Europe, is the source of Burgundy pitch, and of the so-called Jura turpentine.

Burgundy pitch has long been used for making certain special types of varnish and other preparations and in medicine—mainly for plasters. The small quantities now used in medicine are said to be mainly derived from the Swiss side of the Jura mountains, particularly from the forests of Soulec and Framelan in the Delemont valley (G. E. TREASE 1945). To obtain it incisions are made in the trunk of the tree and the resin that collects in them scraped out after the lapse of some months. It is yellow or reddish brown with a sweetish aromatic taste and is strongly adhesive.

Pinus:—Amber is the fossil resin of various Conifers now extinct, particularly *Pinus succinifera*. Several different forms or varieties of amber have been distinguished (H. WOLFF 1928) but the best known is that generally termed Baltic amber or succinite. It is believed the trees in question previously formed extensive forests in northern Scandinavia. The resin they secreted while living remained after the trees had decayed and at a later period was deposited in an extensive bed of blue earth near the eastern shores of the Baltic. Amber is recovered from this blue earth by mining. Pieces are also washed up by the sea. Occasionally they are to be found on the east coast of Britain. Amber is best known for its ornamental value. The oil obtained from it (oil of amber) has medicinal uses, being sometimes given internally in the treatment of asthma and whooping cough.

Piper:—The root of *Piper methysticum*, pounded and mixed with water, yields "kava", a well known drink throughout the greater part of Polynesia. Kava resin, derived from the same root is reputed (WOLFF) to have medicinal properties (diuretic and disinfectant).

Cubebs, the dried unripe fruits of *Piper cubeba*, collected in the eastern tropics, are both a drug and a spice. The oleo-resin they contain is medicinal (Br. Pharm. Codex 1934).

Podophyllum:—Podophyllum resin is derived from the drug podophyllum, which is the dried rhizome of a North American plant (*P. peltatum*) and also from Indian podophyllum *P. hexandrum* (syn. *P. emodi*) (PURAN SINGH 1912). The resin, which is actually a mixture of resins, is extracted with alcohol. It is pale yellow or yellowish brown with a bitter, acrid taste and has to be handled with care owing to its irritating effect on the eyes. It is a drastic purgative.

Schinus:—The South American tree, *Schinus molle* ("Pepper tree"), now so extensively planted throughout the subtropics as an ornamental and street tree, yields a gum-resin of the mastic type. It is said to consist of about 60% resin and 40% gum with a small quantity of volatile oil (TSCHIRCH).

Sindora:—Resinous wood oils are obtained from two species in the Philippines—*Sindora inermis* yielding "kayu-galu" oil and *S. supa* yielding "supa" oil. In addition to local uses the former has been exported by Chinese traders to Singapore (WEST and BROWN).

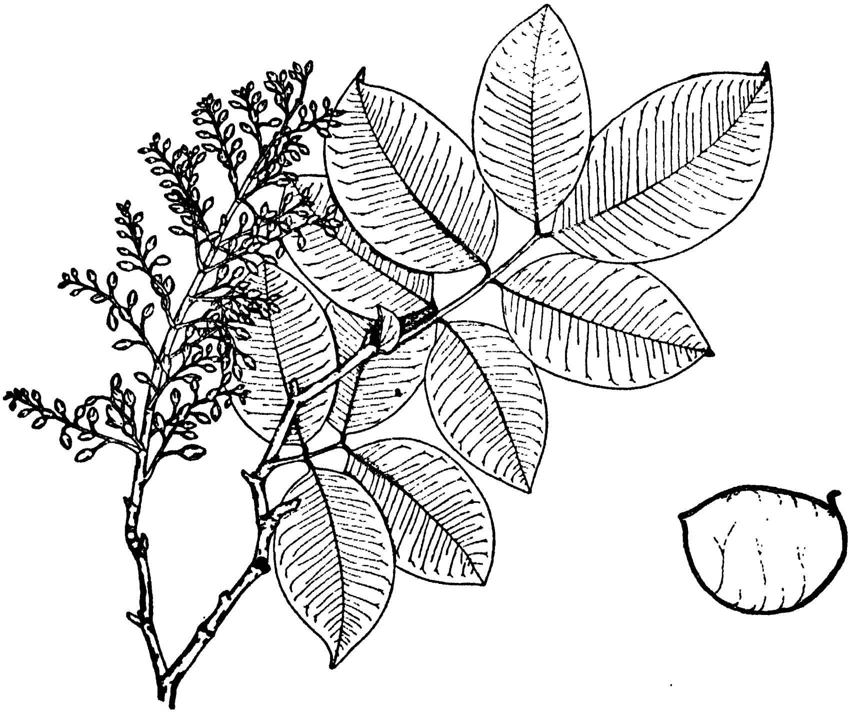


FIGURE 38.—**Sindora inermis** Merr. Another source of resinous wood oil in the Philippines (*adapted from* Philippine Resins, Gums, Seed Oils and Essential Oils by WEST and BROWN).

Spermolepis:—In New Caledonia the Myrtaceous tree, *Spermolepis gummifera* yields a resinous exudation which is mainly a mixture of tannin (80%) and resin (20%) (DE CORDEMOY).

Styrax:—Benzoin or "gum benjamin" is the dried resinous balsam obtained from several species of *Styrax,* forest trees in the Asiatic tropics. Sumatra benzoin (*Styrax benzoin*) is the best known kind and that generally employed for medicinal purposes. The tree is wild in Sumatra and is also cultivated usually on hillside or dry rice land. After seven years growth it may be worked for benzoin. This consists of making horizontal rows of wounds in the wood and bark at different periods. The first wounds merely stimulate the production of resin for the later wounding and yield little or no resin themselves. A knife of sharpened bamboo is used for collecting the partly dried resin from the wounds, care being taken to avoid collecting fragments of bark as far as possible (HEYNE). Benzoin usually consists of white or reddish tears in a brownish matrix and is often exported in blocks. It has a pleasant balsamic odour and slightly acrid taste. Taken internally benzoin acts as a carminative, expectorant and diuretic. It may be applied externally to wounds and sores and is one of the main ingredients in Friar's balsam. Benzoin is also used to fix the odours of incense, skin soaps, perfumes and other cosmetics and for fixing the tastes of certain pharmaceutical preparations. Synthetic gum benzoin is now produced on a commercial scale.

The benzoin of Siam and Indo-China is largely derived from *Styrax tonkinense* and *S. benzoides* and that from the Andes and Bolivia from several different species of *Styrax* such as *S. pearcei, S. aureum, S. camporum, S. ferrugineum* and *S. reticulatum* (BURKILL). A Mediterranean species, *S. officinale,* was exploited for storax in earlier times.

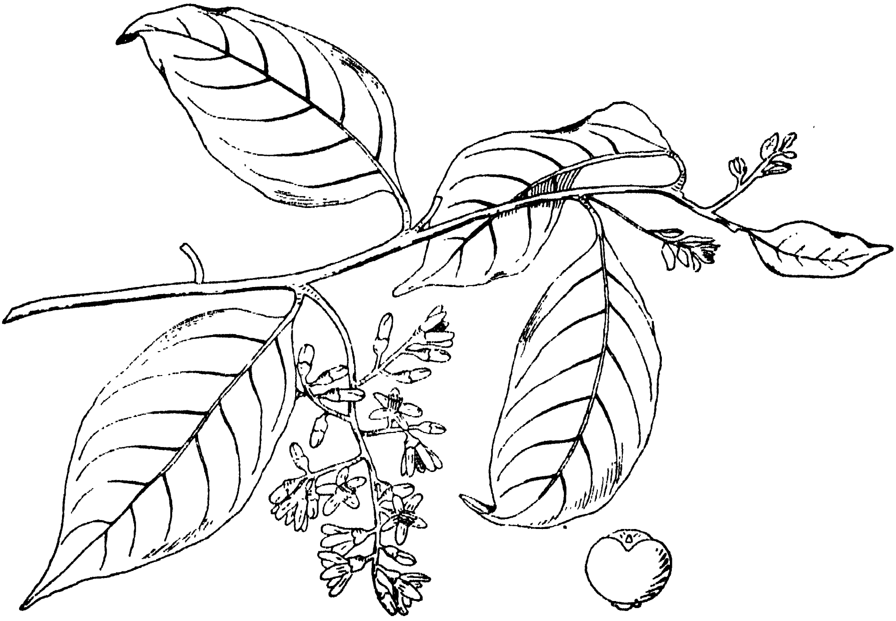


FIGURE 39.—**Styrax benzoin** Dry. The source of Sumatra benzoin.

Thapsia:—This small genus of the Umbelliferæ is restricted to the Mediterranean region. One species at least, *Thapsia garganica* may yield resin freely but it is not known whether it is regularly collected or used (VON WIESNER).

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